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Energy efficiency in a restructuring electricity distribution industry in South Africa: Analysis and policy strategies

LWAZIKAZI TYANI

Submitted to the University of Cape Town

In partial fulfilment of the requirements for the degree of

Master of Philosophy in Energy and Development Studies

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Declaration

I, Lwazikazi Tyani, submit this dissertation to the University of Cape Town in fulfilment of the requirements for the degree of the Master of Philosophy in Energy studies. I declare that, unless otherwise acknowledged, this is my original work and that it has not been submitted in this form or similar form for a degree at any University.

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L Tyani

10th day of August 2000

Dedication

To my loving Mother: I am who I am because of you 'Jwara elikhulu'.

Acknowledgements

I thank Jehovah, the Almighty God, who loves me so much and blessed me with this opportunity and ability to study. My heartfelt gratitude goes to my supervisor and programme leader Randall Spalding-Fecher for his patience and guidance throughout this study, and for giving me time and moral support to complete the study. I also thank Alix Clark and Mark Davis for their support and encouragement. I thank all researchers and staff at EDRC for their wonderful support and encouragement and Tim James who edited this document. I sincerely appreciate EDRC for providing me with the financial support to study.

Lastly I thank my family and friends who supported and encouraged me to carry on, and my little girls Mihlali and Asithandile who have inspired me in their own way.

List of abbreviations

ACE	Association for Conservation of Energy
ACEEE	American Council for Energy Efficient Economy
CFE	Commission Federal de Elecricidad
CFL	Compact Fluorescent Lights
DEA	Department of Energy Affairs
DME	Department of Minerals and Energy
DOH	Department of Housing
DSM	Demand-side management
EDF	Electricité de France
EDI	Electricity Distribution Industry
EEL	Energy Efficient Lighting
EES	Energy Environment Strategy
EFM	Electrification Financing Model
EGAT	Electricity Generating Authority
EIA	Energy Information Administration
ELI	Efficient Lighting Initiative
ERI	Energy Research Institute
ERIC	Electricity restructuring Interdepartmental Committee
ESCO	Energy Service Company
ESI	Electricity supply industry
ESM	Energy Service Management
EST	Energy savings trust
GEF	Global Environmental Facility
GHG	Greenhouse gas
GWh	GigaWatt hour
IEP	Integrated energy planning
IIEC	International Institute for Energy Conservation
IRP	Integrated resource planning
KICs	Key industrial customer
kW	KiloWatt
kWh	KiloWatt hour
MEA	Metropolitan Electricity Authority
NER	National Electricity Regulator

NARUC	National Association of Regulatory Commission
NLRA	Net lost revenue adjustments
NPV	Net present value
OECF	Overseas Economic Co-operation Fund
OFFER	Office of Electricity Regulation
PROCEL	National Electricity Conservation Programme (Brazil)
PURPA	Public Utilities Regulatory Policy Act
RDP	Reconstruction and Development Programme
REC	Regional electricity company
RED	Regional electricity distributor
SADC	Southern African Development Community
SCKEF	Southern Cape Karoo Electricity Forum
SOP	Special revenue allowance and standards of performance
TOU	Time of use
TWh	TeraWatt hour
UNFCCC	United Nations Framework Convention on Climate Change
WET	Wholesale electricity tariff
ZESA	Zimbabwe Electricity Supply Authority
ZEEP	Zimbabwe Energy Efficiency Project

CONTENTS

1. Introduction

1.1 Background and motivation for the study

This research makes recommendations to improve energy efficiency investments by electricity distributors in a restructured electricity distribution industry (EDI). The structure of the EDI in South Africa is under transformation. There are plans to replace the fragmented EDI by a limited number of regional electricity distributors (REDs). The rationale for restructuring is that the current EDI is inefficient, and it is hoped that the REDs will be more efficient in distributing electricity. The key questions addressed in this research are: firstly, how will the proposal to restructure the EDI affect the potential for energy efficiency investments by the new distributors? Secondly, what are the current and planned regulatory measures to promote residential energy efficiency investments in the current and proposed EDI?

Several critical issues that affect implementation of energy efficiency in South Africa motivate this research. The world-wide changes in the electricity industry, such as privatisation with the introduction of more competition and structural changes, put energy efficiency at risk and may cause energy efficiency to be sidelined by utilities (Mainzer 1999). There are two reasons that energy efficiency in South Africa might be affected. Firstly, the proposals to restructure the electricity industry, in particular the EDI, do not consider their possible effect on adoption of energy efficient technologies. It is anticipated that the huge amounts of financial and management resources that will be required at the initial stage of restructuring will make it difficult for utilities to invest in new DSM programmes (Praetorius et al 1998; Van Horen 1998). Secondly, a regulatory framework with mechanisms to encourage utilities to promote energy efficiency is not yet in place (Ellman 1999).

Poor urban households in South Africa are faced with shortages of convenient and affordable energy. The rapid population growth in urban areas, because of the removal of laws inhibiting free movement of people, results in increased levels of urban poverty, unemployment and inequality (Dewar 1994), thereby increasing the number of people who do not have access to convenient and clean energy sources. Therefore by investing in energy efficiency poor communities can have access to affordable and clean energy (Spalding-Fecher *et al* 1999).

The government considers energy efficiency a strategy for the socio-economic upliftment of South Africa's people (DME 1998). As a result it is an integral part of the national energy policy framework, although energy efficiency investments in South Africa are small. Yet the impacts of energy efficiency on the poor residential sector are important because of the social priorities for the upliftment and empowerment of the poor (Spalding-Fecher et al 1999).

The government, through its policy on energy, hopes to make energy services accessible and affordable to all South Africans. This intent is documented in the White Paper on Energy Policy (DME 1998), which states the government's commitment to redress the imbalance in energy accessibility by promoting access to affordable energy services to different groups such as poor households, small businesses, small farms and community services. Energy efficiency can help the government realise this objective.

There is an opportunity to incorporate energy efficiency into the Reconstruction and Development Programme (RDP). Currently, the government at local level is upgrading services and infrastructure through its RDP, which amongst other things involves building of low-cost houses. If energy efficiency measures could be incorporated into the building structure of these houses, households and electricity distributors could benefit. For example, projects such as improving thermal efficiency of low-cost housing (e.g. installation of ceilings) and installation of efficient lights can improve energy services and help households reduce their energy bills, whilst the distributor saves on capital investments in electricity distribution (Van Horen & Simmonds 1998; Spalding-Fecher et al 1999).

Energy efficiency is a public good, and so its provision has traditionally been the responsibility of the public sector (Clark 1999). Public goods are those goods and services that affect the common interest of a community; their benefits are indivisible and nobody can be excluded from enjoying them. These goods will not be produced by individuals acting in isolation even when it is clearly best for the whole community. Because of their jointness of supply and impossibility of exclusion, they provide spill-over benefits and costs to third parties. From an economic perspective, they can create inefficiencies and affect price signals. For that reason, public or collective action becomes necessary to promote and ensure efficient performance (Mielnik 1999). Therefore the benefits that result from the use of energy efficiency programmes, such as improved environmental quality, reduced investment cost of additional capacity and reduced risk of supply interruptions, accrue to everyone in the community.

1.2 Energy efficiency

Energy efficiency is one of several demand-side management (DSM) strategies. DSM is the planning and implementation of those utility activities designed to influence customer use of electricity in ways that will produce desired changes in the utility's load shape, such as the pattern and magnitude of utility's load (Gellings 1996).

Energy efficiency as a DSM strategy encompasses efforts to decrease energy consumption of a particular end-use. Its goal is to reduce energy consumption and peak demand growth (Swisher 1997). Energy efficiency is increased when an energy device, such as a household appliance, automobile engine or steam engine undergoes a technical change that enables it to provide the same service (lighting, heating, motor drive) while using less energy (Sissine 1998). Buildings can be made energy efficient through the use of certain materials such as attic insulation, components such as insulated walls, and design aspects such as solar orientation and shade tree landscaping. Energy efficiency is not the same as energy curtailment, which involves a decrease in output or service to curb energy use. That is, energy curtailment occurs when saving energy causes a reduction in services or sacrifice of comfort (Sissine 1998).

In contrast to supply options, energy efficiency puts a downward pressure on energy prices by curbing demand instead of increasing supply. This means that energy efficiency provides additional economic value by preserving the resource base and reducing pollution. This quality defines energy efficiency as a pollution prevention technique and as a key resource for sustainable development on a local, national and global basis (Sissine 1998).

1.3 Energy efficiency in South Africa

Energy efficiency is documented in the White Paper on Energy Policy as a policy strategy to achieve economic efficiency, social equity and environmental stability. The government states that it will establish voluntary guidelines for thermal performance of housing, introduce a domestic appliance labelling programme and undertake publicity campaigns to ensure that appliance purchasers are aware of the purpose of appliance labels (DME 1998). Although the government has initiated some of these programmes, some have fallen by the wayside, since the government does not have enough expertise and capacity to implement them.

In practice it is Eskom, the main electricity utility, that has plans to pursue investment in energy efficiency in South Africa. As part of their integrated electricity planning process, Eskom examines the various scenarios to meet the projected long-term demand for electricity by its various customers, consistent with an acceptable quality of supply in the least cost manner. Energy efficiency is a component of the overall DSM strategy of Eskom stated in its integrated electricity plan (IEP), which includes strategic load growth, interruptibility, load shifting, energy efficiency, customer generation and energisation (Eskom 1997), which are further discussed in section 3.3.1.

With regard to energy efficiency, Eskom is interested particularly in residential DSM as a strategy to reduce the impact of domestic peaks on the national electricity load and related costs (Van Horen et al 1998). This is because Eskom foresees that the dramatic increase in the number of domestic consumers due to electrification will have implications for the generation, transmission and distribution load curves (Eberhard & Van Horen 1995). Eskom has thus identified an energy efficient lighting project as one of the ways to achieve energy savings in the residential sector (Bredenkamp 1998). Even though lighting contributes less than 10% to the utility's load profile, lighting demand has a high degree of coincidence with peak demand for cooking, space heating and water heating, especially in winter when peak occurs in the evening because daylight fades earlier. Therefore energy efficient lighting will help in reducing the electricity bills of low income and previously disadvantaged groups in South Africa, whilst at the same time reducing greenhouse gas emissions. Moreover, expenditure on an additional power station to cope with increased demand at peak periods will be avoided and this will boost the South African economy since energy savings for the country as a whole will be provided (Eskom 1999).

1.4 Research design

1.4.1 Objectives

The overall objective of this research is to examine the potential impact of the proposed structure of electricity distribution industry on energy efficiency. Its specific objectives are as follows:

- to investigate energy efficiency activities in the current and proposed distribution structure;
- to determine the financial implications of energy efficiency investments on the financial position of the proposed REDs;
- to investigate the current and planned regulatory measures that encourage distributors to promote energy efficiency;

- to formulate recommendations that will ensure promotion of viable energy efficiency in the proposed structure of the EDI.

1.4.2 Scope and limitations of the study

This research uses the Western Cape as a case study to investigate broader national issues. It investigates both present and projected implications of the structure of the EDI in energy efficiency and focuses on three issues. The first is the impact of the EDI structure on energy efficiency oriented DSM. The second is the financial implications that would result from energy efficiency measures. The third is the present and projected regulatory measures that will assist distributors in promoting energy efficiency. This research has been limited to eight months (April to November 1999) observation. Because this research was carried out in a dynamic policy environment, only policy proposals through November 1999 were considered.

Because of the time factor the scope of this research is limited to specific distribution and energy efficiency programmes. The research was only able to look carefully at one distribution area (Western Cape). There was no time to follow through the implications of different recommendations on energy efficiency (for example the net-lost revenue adjustment against other decoupling mechanisms) and remaining uncertainties since the electricity distribution industry is not finalised.

1.4.3 Data collection and methodology

Information has been collected from literature and interviews. Literature sources that were consulted include research reports, journal and newspaper articles, books and workshop materials that emanated from workshops held on the subject of restructuring and DSM. Telephone interviews were held with authorities in the EDI and the National Electricity Regulator (NER). The focus of EDI interviews were Eskom Distribution in the Southern Cape and Mossel Bay municipality, whilst in the NER the General Manager for regulation was interviewed.

The research also involves a financial analysis of two potential energy efficiency projects from a distributor perspective. These potential energy efficiency projects are energy efficient lighting (replacing incandescent bulbs with CFLs) and thermal improvements to low-cost housing (installation of ceilings). The analysis shows revenue impacts of energy efficiency investments on the regional electricity distributor (RED). The financial impacts of energy efficiency investments are tested on the Western RED. Its projected financial position prepared by Van Horen and Thompson (1999) is adjusted to determine the financial impact of investing in energy efficiency projects. Van Horen and Thompson produced financial positions of the REDs in a study they undertook to analyse the impacts of the electrification programme. The analysis was based on the provisional boundaries of REDs as proposed in the Electricity Interdepartmental Restructuring Committee (ERIC) report, which is government's document that lays out the electricity restructuring process.

1.5 Overview of chapters

This document is divided into five chapters. This chapter provides an overview of the study. Chapter Two introduces a theory of DSM and country case studies of DSM and energy efficiency experience. Chapter Three provides a summary of the current and proposed EDI structure, its implications for energy efficiency, and planned regulatory mechanisms. Chapter Four presents the results of a financial analysis of two energy efficiency projects; efficient lighting and thermal improvements to low-cost housing and their impact on the financial viability of the Western RED. Chapter Five synthesises the research findings and proposes policy and regulatory mechanisms to promote energy efficiency.

2. Theory and practice of demand-side management

2.1 Introduction

This chapter focuses on the theory and practice of demand-side management (DSM) to identify the extent of implementation of energy-efficiency oriented DSM in other countries. The chapter begins with the theory of DSM, including a definition of DSM, evolution of DSM, DSM strategies, motivation and barriers. To illustrate the practice of DSM some country case studies are provided including energy efficiency programmes, implementation techniques and what mechanisms were use to encourage investment in energy efficiency oriented DSM.

2.2 Definition of DSM

Demand-side management was initially defined as 'the planning and implementation of those utility activities designed to influence customer use of electricity in ways that will produce desired changes in the utility's load shape, the time pattern and magnitude of utility's load' (Gellings 1985). The rationale behind this definition was to change from using technology or hardware as the driving force behind programmes, to using DSM as the marketing strategy that will specifically recognise and promote a customer focus. In this context DSM provided an integrated look at technology options, customer needs and utility requirements. The bottom-line in this approach was to convince the supply-side planners that demand need not be considered as fixed (Gellings 1996). Later it was suggested that DSM definition be changed to: 'DSM involves the planning and implementation of utility activities designed to influence the time, pattern and/or amount of electricity demand in ways that would increase customer satisfaction, and co-incidentally produce changes in the utilities' load shape (Gellings 1989). According to Gellings (1996), this definition has not been widely adopted even though it is broad and has many merits. Instead, in practice DSM encompasses two broad categories of energy efficiency and load management (these are discussed in detail in section 2.4), with emphasis on reducing the need for electrical energy and generation capacity.

2.3 Evolution of DSM

DSM started off in the United States as energy conservation and load management, which was a priority after the 1973 Arab oil embargo (Sioshansi 1996). Before the 1973 Arab oil embargo, energy prices in general and electricity prices in particular were low and were falling with increased consumption. Utilities had no incentives to promote energy conservation and consumers had little or no interest in participating in such activities. The 1973 energy crisis resulted in dramatic increases in oil prices. As a result, electricity prices also increased, particularly in areas that relied heavily on oil and natural gas for electricity generation. In response to the energy crisis, efforts were made to restrain electricity demand growth, primarily through conservation and load management. Energy conservation meant reducing superfluous consumption as well as doing without or getting by with less. Load management programmes focussed on shifting consumption to off-peak or reducing customer use at the time of high utility system loads. Utilities embarked on programmes to convince customers to use less energy during heavy demand periods. According to Gellings (1996), to achieve this goal utilities emphasised conservation of energy with technology as the driving force. Utilities maintained an inventory of energy saving options, and would test hardware to provide information to customers about possible energy savings from technology adoption.

In the 1980s oil prices collapsed and thus the high interest in energy conservation and load management faded. Customers lost interest because energy was once again plentiful and cheap and there was no impending crisis. Utilities learned that successful energy conservation can significantly cut into their kWh sales and hence put upward pressure on their tariffs. Consequently utilities gradually and quietly phased out some of their energy conservation and load management programmes (Sioshansi 1996).

In the mid 1980s interest in energy conservation and load management came to the fore again, due to pressure from a small but highly vocal number of environmental advocacy groups who were alarmed by the decline of utility-sponsored energy conservation and load management programmes. The message of the environmentalists was that energy conservation would prevent local pollution associated with burning fossil fuels. Because of this pressure from environmentalists, utilities were forced to reconsider energy conservation and load management (Sioshansi 1996). However, energy conservation and load management programmes were less customer-friendly since they relied on using technology as their driving force. As a result the term demand-side management emerged. 'DSM was the first marketing strategy that specifically recognised and promoted customer focus. Instead of conducting "what if studies" on individual technologies, DSM allowed an integrated look at technology options, customer needs and utility requirements' (Gellings 1996).

Consequently regulators forced utilities to adopt and implement DSM principles. In the late 1980s, for example, US regulators in a number of key states entrenched DSM as a legitimate profit-making practice by offering utilities financial incentives to engage in DSM (Sioshansi 1996). DSM programmes involving the use of rebates and incentives to promote the purchase of efficient equipment for example became widespread (Gellings 1996). This approach, driven largely by regulatory pressures, was termed 'regulatory DSM'. Various concerns were raised regarding this regulatory-driven DSM. Although the energy conservation activities were broadly beneficial to society, it was not clear what role utilities should take in promoting it (Khan 1991). The minimalist view suggested that utilities should limit their activities to informational, programmes because the utility was seen as uninterested or unsuited to promote activities that would reduce its market. On the other hand, a more activist view favoured direct intervention that would include financial incentives for conservation and efficiency as well as other forms of DSM.

At the same time regulatory DSM came under increasing criticism. First, some objected that, while DSM programmes were funded through a broad tax on all customers, only customers participating in the programmes benefitted. Second, some observers were suspicious of the claimed energy savings and the overall effectiveness of DSM programmes. Others questioned the legitimacy for utilities or regulators to promote energy efficiency. They were not convinced of the fundamental market failure that had to be fixed through regulatory intervention (Sioshansi 1996).

In the US utility investment in energy efficiency and load management programmes were informed by the integrated resource planning (IRP) concept in the 1980s. The IRP process looks at DSM as a resource option that provides conserved energy at a lower cost than new power plants (Nadel & Geller 1995). It considers DSM as well as conventional technologies to arrive at an optimal mix of centralised and decentralised, renewable and non-renewable supply options, taking advantage of cost-effective energy efficiency measures and synergies of energy conversion (Dutt n.d). Initially, IRP focused heavily on DSM; it was seen as the process through which energy efficiency and other DSM activities would become legitimised and part of the resource mix. By 1987, fewer than half of the states had implemented IRP programmes. This was due to regulatory disincentives to DSM created by traditional cost of service tariff-making formulas, which encouraged utilities to over-invest in new plant and oversell to their customers (Mainzer 1999). When regulatory mechanisms to remove financial disincentives to DSM were introduced in 1988, DSM activity and states practising IRP increased. During this time, 34 states adopted IRP and some of the largest utility companies spent millions of dollars on their plans. The emergence of anti-regulatory pressures due to the introduction of competition and restructuring in the electric power industry weakened IRP and put a shadow of uncertainty in regulatory driven DSM in the US and other industrialised countries (Mainzer 1999). Most Public Utility Commissions have suspended their IRP requirements and many are preoccupied with the details of restructuring and do not concern themselves with IRP (Mainzer 1999). The introduction of competition has precipitated some utilities to reduce their DSM efforts and spending (Sioshansi 1996). Several states, including Arkansas, Georgia, Michigan and Nevada, stopped promotion of energy efficiency through utility regulation; instead energy efficiency is now strictly a market product whereby energy efficiency policies have to come from outside the utility sector (DiBiaso 1998). However there are a few states which continue to require IRP for their utilities because they believe that IRP is in public interest and has continued importance (Mainzer 1999).

2.4 DSM strategies

DSM strategies involve a systematic effort to manage the timing or amount of electricity demanded by customers. The aim of DSM strategies is to change the shape of the load curve (Swisher *et al* 1997). Generally, there are four DSM interventions that can be implemented. These are (i) strategic load growth; (ii) load shifting; (iii) interruptibility; and (iv) energy efficiency interventions. These strategies can be grouped into two broad categories: load management and energy efficiency. These are illustrated in Figure 1.

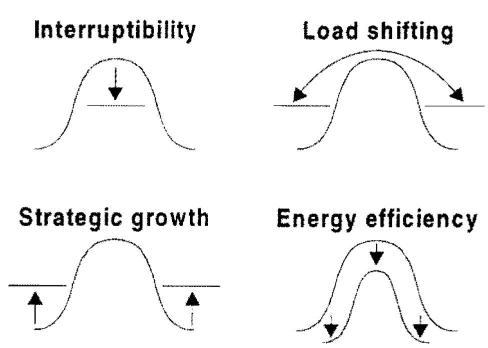

Figure 1: DSM options

Source: Eskom (1997)

2.4.1 Load management strategies

In Figure 1 above, three of the DSM strategies – interruptibility, load shifting and strategic load growth – are load management strategies. Load management programmes include measures that aim to make better use of the existing installed electrical capacity, or to defer the need for new capacity (Swisher *et al* 1997). The primary objective of load management is to modify the load profile, not to save energy. In essence load management programmes shift electric loads from one period to another such as from peak to off-peak periods and do not reduce electricity use. Because they do not save energy, they do not cause revenue losses from reduced electricity sales and do not lead to increased electricity prices (Nadel & Geller 1995). A short description of each of the load management strategies is provided below.

- *Strategic load growth* involves the creation of additional electricity sales where there is excess capacity with due regard to the time of day and point on the network at which the electricity is consumed (Clark 1999).
- *Load shifting* is an attempt to reduce peak load, which involves the modification of the time at which a customer uses electricity. This is achieved primarily through the provision of price-based incentives such as time of use (TOU) tariffs and real time pricing (RTP). TOU tariffs vary the cost of energy by season or time of day and are higher during periods of peak demand and lower during off-peak periods. RTP pricing varies electricity prices by day and for several different periods during the day. Prices are sent to customers a day or so in advance and customers can seek to adjust their loads in response to these price signals (Swisher et al 1997). Direct utility load control is also used, for example where customers may allow a utility to control their hot water geysers and air conditioners in return from some (usually tariff based) incentive. Both the utility and the customer should therefore benefit from the transaction (Swisher et al 1997; Clark 1999).
- An *interruptible* load agreement allows the power supplier to interrupt power supplied to a portion of a customer's premises for a limited period of time in return for compensation (Clark 1999). An interruptible load agreement could also occur where the customer reduces electricity demand in response to price signals from the utility. The utility benefits from these agreements as it enables operation at lower reserve margins (in the event of plant failure, the utility disconnects these customers until contingency plans can be implemented). The customer benefits through a lower average electricity tariff (Swisher *et al* 1997).

2.4.2 Energy efficiency

Energy efficiency is one specific type of DSM intervention where efforts are made to decrease the energy consumption of a particular end-use while maintaining the same service. Its goal is to reduce energy consumption and peak demand growth without compromising service (Swisher *et al* 1997). Therefore energy efficiency programmes save both capacity and operating costs. Energy efficiency DSM primarily involves conversion to more efficient end-use electrical technologies and the adoption of more efficient behavioural practices often related to energy conservation. Some conflict of objectives arises when utilities have excess capacity. Only when the avoided new construction costs are greater than potential revenue, are energy efficiency initiatives financially viable for integrated utilities (Clark 1999).

2.4.2.1 Energy efficient technologies

There are energy efficient technologies that are used to reduce industrial commercial and household energy consumption. Whilst these technologies improve equity of access to energy services, they also reduce environmental and health impacts of energy generation, distribution and consumption (Simmonds 1995). At household level the two main arenas in which technologies can be applied to reduce energy consumption are design techniques to improve the thermal efficiency of the building and technological improvements in the energy efficiency of appliances.

Thermal performance of housing

Thermal performance of a dwelling can be improved by employing climatic design techniques, which require only climatic design knowledge at no cost, and by installing some measures at a low cost. Climatic design techniques involve planning the site and designing buildings to take advantage of the solar energy and natural ventilation (Nadel *et al* n.d; Watson 1983). Simple low-cost measures include installing insulation, radiant barriers, reflective paints and reflective windows (Nadel *et al* n.d).

Measures to improve thermal performance of houses can be installed while a house is being built and in existing houses. According to Nadel *et al* (n.d.) it is cheaper to install measures to improve thermal performance of a house while it is being built than to retrofit these measures later, because conservation measures can be installed for only incremental cost beyond present construction practices. Measures to encourage the adoption of thermal improvements while houses are being built have ranged from simple information programmes to comprehensive programmes that include education, codes and standards, technical training and financial incentives. Information and education programmes have sought to educate consumers about the economic and thermal comfort benefits of thermal improvements to houses. Codes and standards consisted of utilities specifying performance or prescriptive standards for an energy efficient houses, certifying new houses that are in compliance with its standards and promoting the advantages of certified houses to potential homebuyers. California in the US has building standards that extend to lighting and air handling efficiency. Sweden has some of the strictest building thermal standards in the world. As a result, Swedish housing is among the most comfortable and energy efficient despite the severe climate (Swisher n.d). To offer technical training and financial incentives some utilities provide rebates to builders to train on how to include thermal improvement measures in a house and to arrange for higher loan limits for certified efficient homes (Nadel *et al* n.d).

Energy efficient appliances

Energy efficient appliances are required to reduce energy consumption for lighting, cooking, water heating, space-heating/cooling and refrigeration. Only energy efficient appliances for lighting are discussed in this section.

In low-income households, the most common use for electricity is lighting and many energy efficiency programmes in developing countries have targeted the poor by focusing on end-use efficiency on lighting. The objective of these programmes is to replace widely used inefficient incandescent lights with more efficient compact fluorescent lights (CFLs). According to Dutt (n.d) CFLs can last up to ten times longer than incandescent lightbulbs and consume a quarter or less of the electricity needed to produce the same amount of light as incandescent lights.

Barriers that inhibit the use of CFLs relate to price, availability and limited information, cost-effectiveness and appearance. The price of a CFL bulb is higher than that of an incandescent bulb (Dutt n.d & Nadel *et al* n.d). This discourages purchases by low-income households who are affected by scarcity of cash, making them sensitive to first cost. CFLs are generally not available in supermarkets and other retail stores. The availability of CFLs is limited in many developing countries where they are not manufactured domestically. Information about the technical and economic characteristics of CFLs is limited and often comes from manufactures that are not considered as reliable sources of information (Simmonds 1995). If CFLs are imported, import tariffs reduce the cost-effectiveness of CFLs). In addition the cost-effectiveness of CFLs is reduced where the price of electricity is subsidised such that it falls below the average and long run marginal cost of supplying electricity (Simmonds 1995). Customers find that CFLs' bulkiness makes it difficult to blend with light fittings designed for use with incandescent bulbs (Nadel *et al* n.d).

A number of programmes have been used to promote adoption of CFLs. These programmes differ in terms of who should implement them, how to finance them, what delivery channel is used to get them to consumers and how and whether it is necessary to regulate them.

Information programmes

Information programmes are strategies to disseminate information on energy conservation measures or more efficient technologies. These can be developed by government agencies or by energy service companies (ESCOs). Information programmes are meant to improve customer and electricity distributor awareness about CFLs. For example, the Efficient Lighting Initiative in South Africa will use marketing and educational tools, special events and stakeholder forums to improve CFL awareness. Marketing tools include advertising techniques targeting the residential lighting market. Special events include product launches, school visits, trade fairs and competitions. Stakeholder forums are involvement of all stakeholders including CFL manufacturers, household consumers, electricity distribution companies, housing developers and other relevant government agencies (Eskom 1999). However information programmes are more effective when combined with other measures (Simmonds 1995). In industrialised countries, expenditure for information programmes are incurred by the implementing utility where the regulator provides regulatory incentives that allow the utility to recoup the energy efficiency related expenses.

Leasing

Leasing programmes are commonly for CFLs where the utility can lease them to customers at a specified cost per month. The customer repays the utility by spreading the payment for their purchases of CFLs over their electric bills (Nadel *et al* n.d). This procedure can achieve high participation rates. Electricité de France (EDF) has had a successful leasing programme which resulted in the participation rate of 37% of eligible households and CFLs sales at an average of 8 bulbs per household (Simmonds 1995).

Rebate programmes

This involves issuing coupons to enable customers to obtain reductions in the purchase of one or more CFLs. The reductions are usually between 20% and 50% of the selling price and apply to a limited number of bulbs (Nadel *et al* n.d). These programmes, usually initiated by electric utilities, may be carried out in collaboration with manufacturers and retailers (Simmonds 1995). Many utilities offer cash rebate payments to buyers of energy efficient equipment, while some offer rebates to sellers of efficient equipment. In the residential sector, rebates have been offered for the purchase of efficient appliances and CFLs and have proven very cost-effective at promoting basic lighting and equipment improvements. For rebate programmes to succeed in developing countries, the rebate amount for the equipment should not be greater than the extra first cost for more efficient models (Swisher *et al* 1997).

Direct installation and free distribution programmes

Direct installation involves actual installation of equipment by the utility or a utility representative such as an ESCO. This can be done at a cost or free of charge. Its objective is to minimise barriers to end-user participation by providing comprehensive installation services to the customer. These services may include auditing and assistance both with the installation of energy-efficiency measures and with financing (Nadel & Geller 1995). Direct installations at a cost to the customer are a strategy where the utility shares half of the cost of the CFL as well as implementation cost with the customer. The utility can also offer CFLs free of charge to their low-income customers and offer installation assistance. This can be done by collaborating with community based associations which approach these households and arrange the free distribution of bulbs (Nadel *et al* n.d). In industrialised countries direct installations are usually funded by the utility, in developing countries funds are obtained from international lending institutions. In Mexico, for example, the Ilumex project, designed to replace approximately two million incandescent bulbs with CFLs, was carried out by the Mexican electricity utility, Comision Federal de Electricidad (CFE). The project was funded by internal CFE funds, a loan to CFE by the World Bank and grants from other international lending institutions (Simmonds 1995).

2.5 Motivations for implementing energy efficiency

Utilities and governments are driven by important motivations to carry out energy efficiency. These motivations vary between countries and are influenced by the economic philosophy, political priorities, and socio-economic status of the end-users; they are discussed in this section.

2.5.1 Economic motivations

There are economic motives that drive utilities, customers and governments to implement energy efficiency DSM. The first reason why a utility should invest its funds in energy efficiency DSM programmes is that saving energy through such programmes can cost the utility less than obtaining the equivalent amount of power from new supply-side options (Woolf & Mickle 1993). Programmes should be designed so that money spent in reducing customer demand for electricity is less than money saved on generating, purchasing, transmitting or distributing electricity. DSM programmes can result in a net reduction of overall costs to the utility, and therefore represent a resource for electric utilities to meet customer demand, in the same way that a new power plant or new electricity purchases do. Secondly, utility DSM investments have the potential to offer economic benefits to the utility's customers and shareholders, since DSM resources can reduce an electric utility's total system costs of providing electricity services (Woolf & Mickle 1993).

Consumers are driven by desire to save money by reducing their expenditure on energy. Expenditure on energy consumes a substantial portion of a poor household's income. Evidence from South Africa shows that the poorest group of households spends the most on energy as a proportion of their income (Thorne 1995). If end-use efficiency increases, thereby reducing the energy bill of the consumer, a portion of consumer income will be released for other purchases (Nadel et al n.d).

Economic concerns that motivate implementation of energy efficiency by governments are concerns about loss of international competitiveness, meeting debt service repayments, economic development and energy savings. Most countries are concerned about the loss in international competitiveness from using energy and electricity less efficiently. For example, Japan and West Germany have increased their energy efficiency at a faster rate than the US, overtaking US competitive advantage in some sectors (Simmonds 1995).

Finally, in some instances, some countries are experiencing high energy-related debt and therefore opt for end-use energy efficiency as a means to reduce electricity consumption to decrease energy-related debt and meet debt service requirements (Simmonds 1995).

2.5.2 Environmental motivations

Energy efficiency was implemented initially more as a response to the changing market conditions than because of the desire to change environmental quality. Regulators, for example, gave utilities financial incentives to encourage less consumption of power. Such regulatory incentives helped motivate utilities to encourage energy efficiency in ways that benefited both them and their customers, while helping to reduce the environmental impact of electricity production and use (Hirst 1999). As a result, environmental concerns have become the major driver behind growing utility integrated resource planning and energy efficiency efforts around the world. Regulators have attempted to assign environmental costs to be incorporated in utility resource planning decisions (Rabil & Sioshansi 1993).

Energy efficiency has gained increasing attention as a means of meeting global environmental commitments as set up by the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC was negotiated by countries to face the challenge of climate change due to human induced emissions of carbon dioxide and other greenhouse gases (GHGs). A Protocol to the Framework Convention was negotiated and completed at the Third Conference of Parties in Kyoto, Japan in December 1997. The Kyoto Protocol establishes legally binding GHG emissions limits for 38 industrialised countries whereby these countries are expected to reduce their GHG emissions by at least 5% compared to the 1990 levels, in the 2008-2012 time period (Geller et al 1998; Wamukonya & Spalding -Fecher 1999).

Even though the USA, which accounts for about a quarter of the total emissions, has not yet ratified the Protocol (Wamukonya & Spalding-Fecher 1999), it has developed energy efficiency policy initiatives that could greatly help to achieve its Kyoto target (Nadel et al 1998). It has recognised that promoting greater energy efficiency can substantially reduce GHG emissions without harming the economy. This will be achieved by promoting better technologies such as more efficient appliances, lighting, vehicles and industrial processes rather than taxes or heavy-handed regulations (ACEEE 1998). In European countries, the justification for energy efficiency policies is less related to energy policy and more to environmental policy concerns for the greenhouse effect and the need for abatement strategies. For example, Norway's energy conservation programme has been influenced by a concern for the environment, specifically issues of global warming and ozone depletion (Simmonds 1995). The World Bank, through its draft Energy-Environment Strategy (EES) also recognises the importance of energy efficiency in reducing local and global externalities. The EES states that while energy efficiency addresses GHG emissions it also plays a role in abating local and regional pollution. Techniques that reduce GHGs have a simultaneous and proportional positive impact on emissions of NOx, SOx and particulate matter (Busch 1997).

2.5.3 Security concerns

Energy security is a concern at both national and household levels. All nations want to avoid or reduce reliance on imported oil and gas. Consequently, energy efficiency is regarded as a strategy to reduce the economic risks associated with importing oil and gas. This is based on the understanding that, by decreasing electricity use, the consumption of oil and gas is decreased where these fuels are used to generate electricity (Simmonds 1995).

2.5.4 Equity motivations

Energy equity refers to equality of access to energy services (Simmonds 1995). Physical access and affordability of services are the main factors that influence equity in energy services. One way of widening access to energy services is to promote energy efficiency measures (Thorne 1995).

Inequity in energy service provision exists between and within countries for several reasons. Whilst per capita energy consumption levels are high in industrialised countries, they are very low in developing countries (Pachauri 1990; Reddy & *Goldemberg 1990). In addition, the energy situation in developing nations varies between countries and within the different regions of the country. Patterns of energy consumption and supply in rural areas are different from those in urban areas. Approximately two billion people live in rural areas where access to electricity is still limited (Pachauri 1990). Whilst energy efficiency is not the only way to remove inequity in energy access and rural poverty, the growth in demand for energy in the developing countries could be reversed through energy efficiency improvements, because energy efficiency could provide more services with less energy input.The scope of efficiency improvements is large, and programmes for efficiency improvements must be promoted and vigorously implemented (Pachauri 1990).

2.6 Barriers to implementation of energy efficiency.

Given the wide range of motivations, one might ask why utilities, customers, and governments are not more active in promoting energy efficiency. This is because a number of barriers inhibit customers, utilities and governments in implementing DSM measures. These barriers are discussed in this section. The term 'market barrier' in the efficiency literature refers to market conditions that reduce energy-efficiency investments relative to an estimated cost-effective level (Sutherland 1991). Conservation proponents argue that the root cause of market barriers emanates from how energy systems have evolved, as well as from social attitudes, institutional structures, and market characteristics (Eyre 1998). These market barriers discourage energy efficiency investment and, as such, are market failures that require government intervention. A market failure is a condition in any market that results in an inefficient allocation of resources. Government policies should focus on eliminating or at least reducing market barriers so that an economically efficient level of conservation and consumption can be achieved (Sutherland 1991).

2.6.1 Barriers to customer investment in energy efficiency

- *Lack of knowledge.* Many energy consumers are not aware of the potential savings that can be achieved from energy efficiency, nor do they have the knowledge and technical skills to install energy efficiency measures (Woolf & Mickle 1993; Simmonds 1995).
- *Limited access to capital.* Energy efficiency measures often require upfront capital in order to achieve long-term savings. Domestic customers and small businesses often do not have up-front capital, or they reserve it for other investments.
- *Rapid payback requirements.* Generally, customers (domestic, commercial and industrial) will not undertake investments in energy efficiency unless the payback period is short, even though from an national economic pespctive they may be good investments.
- *Split incentives.* Electricity consumers who rent their homes or offices do not have an interest in long-term investments necessary to improve the energy efficiency of buildings, because they do not own the buildings. On the other hand, landlords do not have an interest in such investments because they do not pay the electricity bills.
- *Inappropriate price signals.* Electricity rates often do not reflect the full marginal cost of producing electricity (especially the environmental costs), nor do they fully reflect the variation in costs between peak, shoulder and off-peak periods.
- *Lack of financially rational decision making.* The electricity bill is often a small part of customer's budgets, and rarely receives appropriate attention. In addition, unrelated, non-economic issues such as appearance, fashion, trends and habits often govern customers (Simmonds & Clark 1998; Barberton 1999).
- *Low energy prices.* Energy prices usually do not reflect the true cost of supplying energy (Limaye 1993). Whilst prices in most developed countries are set with the objective of covering at least the full financial costs of supply, many developing countries' energy prices do not cover the economic or full financial costs of supply. This means that energy consumers do not face prices that encourage them to use energy efficiently, select the most economic fuel, or use the technology that would best meet their needs (World Bank 1993). For example, low electricity prices in Eastern Europe and in Africa are factors that currently inhibit both interest and investment in DSM (Boyle 1996).
- *Absence of codes and standards.* The absence of specific efficiency standards, such as mandated energy performance codes and standards and inadequate legal structures, limit the possibility of energy efficiency (World Bank 1993).

- *Availability of energy efficient technologies.* Most energy efficient technologies and materials are manufactured in industrialised countries and are imported by other countries. Imported technology and materials carry heavy import duties in most developing countries and add to the cost of a product. This makes it difficult for manufacturers to introduce more efficient products, particularly when they do not have a collaborative arrangement with companies in industrialised countries (Sathaye & Gadgil 1992). The duties and taxes on imports to Thailand, for example, vary from 30%-60% in 1991. At that time, products that promised to reduce electricity consumption were not available domestically. This led to a high cost of imported energy saving technologies so that they were not cost effective (IIEC 1991).
- *Lack of information.* Customers lack information about energy saving mechanisms. In particular, awareness of appliance efficiency is limited, as are relative costs of using different appliance/fuel combinations (IIEC 1991; Mehlwana 1998). In addition, lack of public awareness about energy efficiency, impact on the level of public support for energy efficiency initiatives, the take-up of energy efficiency measures, the level of participation in energy saving initiatives and the kinds of mandates voters give their public representatives (Barberton & Clark 1999).

These market barriers must be overcome if customers are to adopt an economically efficient level of energy efficiency measures. Utilities can play a critical role in overcoming these barriers, by providing programmes to customers with information, financial assistance, and technical assistance necessary to install energy efficiency measures. However, the barriers listed below inhibit utilities' investment in energy efficiency measures.

2.6.2 Barriers preventing utility investment in energy efficiency

- *Declining marginal costs in the electricity industry.* The electricity industry has historically been characterised by declining marginal costs to build and operate power plants. As a result the industry's strategy for maximising profits and minimising costs to customers has been to sell as much electricity as possible in order to spread fixed costs over as many kiloWatt hours as possible. This policy was consistent with governments' goal of providing low cost electricity. As a result, governments and regulators established policies which generally encouraged this approach. Because of this profit orientation approach, utilities tend not to pay much attention to DSM measures that encourage energy efficiency (Barberton & Clark 1999).

- *Uncertainty about impact of restructuring.* Many utilities around the world have felt threatened by pending electricity industry restructuring. They are concerned that restructuring would bring uncertain rules and levels of competition. Utilities have been responding to this threat by cutting all expenses deemed to be non-essential, including utility DSM programmes (Barberton & Clark 1999).

- *Limited utility experience or capability in energy efficiency programme implementation.* This problem is acute in developing countries where utilities are slow to implement efficiency measures, often because of limited experience or capability in energy efficiency programme implementation (Sathaye & Gadgil 1992). Senior utility executives tend to see themselves as being in the business of producing and supplying energy not energy services. Energy efficiency runs counter to their perceived interests: they generate more revenues by selling more energy. Some evidence from South Africa shows that capacity barriers to energy efficiency seem to predominate at the municipal level. Municipal electricity distributors under-invest in energy efficiency because of a general lack of capacity due to lack of information on different DSM opportunities, methods and tools, their benefits and costs and how they are implemented (Barberton & Clark 1999).

- *Lack of financing.* There is a shortage of capital (especially foreign exchange) available to finance energy conservation programmes and individual projects (World Bank 1993; Limaye 1993; Simmonds 1995). This shortage occurs across private and public owned utilities. Many utilities – in particular municipal distributors – do not have capital to invest in energy efficiency because they are already heavily involved in debt, or they have allocated their capital for use in another social investments such as roads and sewerage (Barberton & Clark 1999).

2.6.3 Barriers inhibiting investment in energy efficiency at government level

- *Resource constraints.* Implementation of energy efficiency requires capital and human resources. Governments are faced with shortage of capital to finance energy efficiency programmes (Simmonds 1995). In South Africa for example, initiatives such as the establishment of an energy efficiency agency and environmentally sound low-cost project can not be carried forward because the government lacks funds to do so (Barberton & Clark 1999).

- *Weak institutions.* Most developing countries do not have agencies responsible for formulating, co-ordinating, implementing, and monitoring energy efficiency policies and programmes (Simmonds 1995; World Bank 1993). In all developing countries there is a serious lack of personnel with adequate technical, financial, economic, managerial and energy planning skills to identify and implement specific energy conservation policies and programmes (World Bank 1993).

- *Lack of information.* Policymakers lack awareness of energy conservation benefits, potential, practices and technologies (Limaye 1993).

2.7 Country case studies on DSM

Despite the existence of barriers there is evidence pointing to the implementation of DSM in countries in various regions of the world. Some countries are at an advanced stage, whereas others are still learning about DSM. DSM experience in different countries is discussed below.

2.7.1 DSM in the United States of America

Initially, DSM oriented energy efficiency programmes in the United States mainly comprised education and loan programmes designed to educate and provide finance to consumers and businesses to invest in cost-effective DSM measures (Gellings 1989; Boyle 1996). Educational efforts focused on energy audits and printed materials, while energy efficiency directed loans were offered at subsidised interest rates. Apart from these measures, utilities also encouraged customers to work with energy savings companies (ESCOs) which were established to help customers install energy saving measures, often under shared energy saving arrangements. Later on, utilities learnt that education alone results in limited energy savings and that loans, or shared savings agreements, did not suffice (Clark 1999). Education programmes for example, were found to produce very low savings, while low-cost loans reached only a few customers (Nadel *et al* n.d). In response to this, some states and regions began to implement integrated resource planning (IRP) processes that, among other considerations, looked at DSM as a planning resource that could provide conserved power and energy at a lower cost than would be incurred by installing a new power plant. Many IRPprogrammes included DSM as a central element and many of these DSM programmes involved rebates. Rebates generally consisted of fixed payments for use of specified energy efficiency measures, such as a $5 rebate for each CFL installed. While these programmes were fairly effective at promoting certain specific types of efficiency equipment, they were not effective in promoting the integrated packages of measures that represented a large portion of the savings potential. Also, while many customers participated in rebate programmes, the majority of eligible customers did not, which left a gap between the savings achieved and the economic savings potential (Nadel & Geller 1995). In an effort to capture a greater share of the savings potential, utilities began to offer comprehensive programmes involving audits, rebates, information and customer involvement (Boyle 1996). The aim of these programmes was to assist individual customers in identifying, financing and installing comprehensive packages of DSM measures and were referred to as "smart DSM" programmes (Geller *et al* 1995; Boyle 1996). This smart DSM was a shift away from rebate programmes towards one-time efficiency opportunities (such as new building construction, CFL replacement, and new equipment investments), market transformation, codes and standards, innovative financing mechanisms, and working directly with equipment manufacturers to develop and stimulate a market for more efficient equipment (Boyle 1996).

Even though these programmes produced the desired energy savings, the introduction of competition in the US brought major uncertainty about DSM. The opening up of the grid network to allow retail wheeling was the major cause of this uncertainty. As a result overall DSM budgets went down by 25%-30% (Nadel & Geller 1995; Boyle 1996). Utilities lost confidence in DSM investment because of the concern over the potential of being left with current grid networks and running costs spread over a lower customer base (Boyle 1996). Within this context, utilities began to offer energy services to customers on a tailor-made basis and required customers to pay for the cost of utility services rendered. This new era of services is often referred to as "energy services management" (ESM). Tailored energy planning assistance includes design assistance, economic analysis, equipment selection support, building re-commissioning, bench marking, verification of savings from equipment, and energy audit services all on a fee-for-service basis. Some utilities have also chosen to focus on market transformation strategies with programmes targetting the residential sector as a whole (Clark 1999). In addition some utilities are returning to first-era DSM such as information, loans and shared savings, because these programme approaches are less expensive to the utility, and it is possible to design more effective programmes than those designed during the 1970s and 1980s (Nadel & Geller 1995).

The developments in the energy saving industry in the US have been primarily driven by several factors including changing customer needs, changes in economic conditions and changes in federal and state regulatory regimes (Clark 1999). Regulatory reforms have played a prominent role in the promotion of energy savings strategies. The first landmark was the Public Utilities Regulatory Policy Act (PURPA) of 1978, which helped focus the electricity industry's attention on the benefits of the increased conservation of electricity energy and load management techniques. In addition the National Association of Regulatory Utility Commissioners (NARUC), and the federal government, through the 1992 Energy Policy Act, endorsed the approach that electricity utility DSM investments should be backed by appropriate financial incentives. Regulators were encouraged to design electricity tariffs so that utility DSM investments were at least as profitable, given appropriate consideration to income lost from reduced sales as investments in supply-side equipment. While this regulatory approach allowed utilities to recover DSM programme costs, it discouraged them from pursuing customer energy efficiency programmes because utilities were not allowed to recover DSM programme expenses when these expenses had not been included in a previous tariff-setting process. In addition, utilities lost earnings opportunities because resources were devoted to DSM programmes rather than to other profit making activities (Clark 1999).

Regulatory reforms which would provide for reduced electricity sales and reduced utility profit were designed to address utilities' reluctance to implement energy efficiency programmes (Hirst & Blank 1994: Woolfe & Mickle 1992). These include the following:

- Decoupling of sales from revenues and profits. This is a way of designing a tariff structure such that the income of the utility is not dependent on sales volume, but on some other measure of service such as growth in number of customers. Decoupling ensures that actual revenues exactly match an established revenue requirement regardless of the sales level.
- Net Lost Revenue Adjustments (NLRAs) are designed to compensate utilities for changes in revenues associated with utility DSM programmes. To implement an NLRA, the utility first estimates the energy and load reductions caused by its DSM programmes for the year in question. These GWh savings are then multiplied by the difference between retail price and short-term costs to get lost energy and lost capacity revenues. The sum of these two products is the net lost revenue caused by the utility's DSM programme. It is called net because it is equal to the difference between reduction in utility revenue minus the reduction in utility costs.
- Expenses programme costs, whereby the utility is able to recover DSM programme costs based on the level of expense in the year in which rates are set.
- Balance accounting method, where programme costs are tracked and reconciled with the amount of DSM expenses that are allowed in rates.

- Capitalising programme costs allows for the utility to earn a return on capitalised DSM just like supply investments and then allows depreciation of this capital.
- DSM mark-up mechanisms, whereby the utility is allowed to earn a higher rate of return on programme costs than on the cost of generation resources.
- Shared savings, whereby the utility is able to share the net economic benefit of DSM with its customers.
- Performance bonuses that allow the utility to earn a specified bonus for each kW and kWh saved from DSM programmes.
- Return on equity bonus, whereby the utility earns a higher (or lower) overall return on equity for good (or bad) performance with DSM programmes.

Evaluations of the impact of these reforms have found that, generally, the desired impact was achieved. Utilities affected by these reforms significantly increased spending on DSM programmes, which in turn delivered significant energy savings (Clark 1999). According to Hadley and Hirst (1995) the largest share of utility expenditures and energy savings was associated with energy efficiency programmes funded by investor-owned utilities. These programmes supplied a substantial portion of load reductions, although large potential peak load reductions also occurred as a result of interruptible load programmes. However, data provided by Energy Information Administration (EIA) shows that utility DSM expenditures decreased approximately one per cent from $2.74 billion in 1993 to $2.72 billion in 1994. Most of these decreases are in energy efficiency programmes (Clark 1999). This is because energy efficiency does not correspond with a utility's efforts to prepare a for competition.

To sustain productive energy efficiency investment during the transition period of the electricity utility restructuring, regulators are starting to use a new cost recovery approach called a non-bypassable system benefits charge on electric distribution services (Baxter 1996). This charge is non-bypassable because it applies to all retail electricity sales and is based on usage (kWh), demand (kW) or a combination of these two. It is utilised to pay for various public benefits including energy efficiency, low-income programmes, R&D and renewables. This approach requires a change in current tariffs, rate structures or cost allocations amongst customer classes (Baxter 1996; Clark 1999). However the effect of this sytem is not known yet because it is relatively new.

2.7.2 DSM in the United Kingdom

Prior to restructuring, the extent to which energy efficiency had been offered in the UK was minimal. The government-sponsored programmes that existed were primarily promoting energy efficiency in buildings (Holt 1995). As a result, at the time of privatisation there was little pressure to consider how to continue providing energy efficiency. A handful of energy efficiency advocates, including the Association for the Conservation of Energy (ACE) urged that energy efficiency be built into the new structure, on both energy resource and environmental protection grounds. OFFER (Office of Electricity Regulation, which oversees regulation of the ESI) on the other hand, believed that, since market forces would meet demands as they arose, no special provisions for energy efficiency were needed. If customers communicated a desire for efficiency measures, markets would develop to serve them (Holt 1995).

Even though competition was introduced in 1989, by 1992 it was apparent that the marketplace was not yielding either demand for or investment in energy efficiency (Holt 1995). There were limited incentives for electricity suppliers to compete for customers, let alone offer energy services as a means of minimising customers' bills because gross profit margins associated with supplying electricity to end-use customers were very low (Mickle 1993).

In the absence of an explicit government directive, the regional electricity companies (RECs)[1] did not promote energy efficiency options. Energy efficiency was put back on the agenda by the Conservative government, which signed the UNFCC[3] making an agreement to reduce in the country's greennhouse gases, particularly CO_2 emissions. This commitment became a campaign issue for the 1992 election. Politicians who were subsequently elected proposed a CO_2 reduction plan that made the electricity utility industry responsible for 25% of the country's CO_2 reduction through energy efficiency measures (Holt 1995). This plan made it clear that utilities were not meant to treat energy efficiency as an energy resource but instead were expected to pursue efficiency to meet an environmental obligation.

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[1] RECs are the regional electricity companies responsible for electricity distribution in UK, which came into being in December 1990 when UK privatised its electricity industry. Originally, there were twelve government-owned distribution companies (twelve in England and Wales, two in Scotland, and one in Northern Ireland) responsible for building and maintaining the local medium and low-voltage distribution system in specific areas. These were privatised intact as regional electricity companies with no change in their commercial scope of activities.

Consequently, in November 1992, the Energy Savings Trust (EST) was established as an independent non-profit body to advise OFFER on matters relating to energy efficiency and to design and oversee energy efficiency programmes. The EST started its mission by setting an efficiency target for each REC to be achieved from energy savings of small customers by March 31, 1998. The target was measured in terms of the number of gigawatt hours to be saved as a result of installed energy saving measures. These customers had to support the energy efficiency programmes with a $1.60 (R10.40) per year wires charge. Funds collected from the wires charge are allocated to RECs, taking into account number of customers and load. Using this allotment, each REC develops programmes to meet its target (Holt 1995).

Another plan that was aimed at encouraging energy efficiency was a revision of the price-cap formula for the supply arm of the RECs. Initially OFFER used the performance-based price-cap formula to control electricity prices. This method allowed electricity companies to make revenue on number of units sold. Because distribution has high fixed costs, each additional kWh sold generates significant profit once fixed costs are covered. Therefore, the price–cap formula posed a strong incentive to distributors to maximise sales, and a strong disincentive to distributors to institute DSM, particularly energy efficiency programmes since they directly result in a high loss of margin (King *et al* 1996 quoted in Clark 1999). To address the disincentives caused by the price-cap mechanism to energy efficiency, OFFER considered adjustments to the price-cap formula .The first adjustment was to partially decouple revenues and profits by basing 25% of the revenues on sales and 75% on the number of small customers served. This was later changed when a proposal adopted by OFFER in April 1995 decoupled half of the revenues for distribution services from the volume of sales. This meant that utilities were allowed to earn 50% of their revenue on volume of electricity sales and 50% on number of customers served (Holt 1995).

Other methods introduced by OFFER in order to encourage distributors to save energy were the establishment of a special revenue allowance and standards of performance (SoP). OFFER elected to adopt a special revenue allowance to be used by distribution companies to achieve end-use energy savings on behalf of their customers. This special revenue allowance was to be raised by collecting the equivalent of one pound from each franchise customer account over the period 1994 to 1998. This money was used to carry out one hundred million pounds worth of energy efficiency activities for customers, with lifetime savings of 6 103 GWh. These funds were administered by the EST.

The SoP required each distribution company to achieve certain energy savings levels. In 1994 the distribution companies were required to save 0.675% of distributed energy. As part of the 1993 supply price control, the Director General of Electricity Supply stipulated that utilities should provide impartial, high quality energy advice where requested by customers. In addition OFFER retained the services of the EST to assess whether projects proposed by distribution companies meet the requirements of the SoP (King et al 1996 quoted in Clark 1999).

According to Holt (1995), because of the EST and OFFER measures, RECs began to offer energy efficiency programmes in 1994. At the beginning of 1995, over 70 REC schemes had been submitted for review, most for residential compact fluorescent lighting and building envelope insulation. RECs participated in national programmes promoting compact fluorescent lights, providing home weatherisation and offering energy advice. At regional level, RECs promoted CFLs and weatherisation of owner-occupied and rental properties. There are some limited examples of RECs initiating DSM programmes independent of performance standards. These are load management programmes, which lower cost but contribute little to energy savings. Nearly all RECs have explored DSM as a tool to postpone the need for distribution upgrades (Holt 1995).

2.7.3 DSM in Thailand

In 1991 and 1992 Thailand established two main initiatives to improve end-use energy efficiency. The first was a utility-run DSM programme in 1991, the second an energy conservation programme in 1992 (Du Point *et al* n.d). In November 1991, the Thai government approved a five-year Demand-Side Management Master Plan that will allocate US $189 million to the purchase of energy efficient equipment in the commercial, industrial and residential sectors. The plan called for the three Thailand electricity utilities – the Electricity Generating Authority of Thailand (EGAT), the Provincial Electricity Authority (PEA), and the Metropolitan Electricity Authority (MEA) – to establish jointly a DSM office which will operate a comprehensive set of energy efficiency programmes. By passing the DSM Master Plan, Thailand became the first Asian country to incorporate energy efficiency formally into its power planning process. Top management at the Thai electricity utilities, with some prodding from the National Energy Policy Council, decided to spend money to produce energy efficiency as a future resource for electric power system (Du Point *et al* n.d). Funding to institute the plan totalled US$ 189 million, of which $15.5 million was obtained from Global Environmental Facility (GEF)[2] funding, \$25 million in soft loan from the Overseas Economic Co-operation Fund (OECF) of Japan, and the balance \$149 million funded by Thai electricity tariff.

An initial target of energy savings of 238MW at 50% of the cost of building a new power plant was passed by the government in 1991 and its implementation began in 1993. The programme was expanded in 1995 with a new target of 1400MW savings by the year 2000. Various DSM measures used to achieve this saving included use of efficient lighting (350MW), efficient refrigeration (50MW), efficient air conditioning to get 370MW, energy efficient drive motors to obtain 125 MW and load management (500MW) (Boyle 1996). These DSM programmes were informed by results of an International Institute for Energy Conservation (IIEC) study, which assessed DSM for the residential sector in Thailand. The IIEC conducted a comprehensive analysis of the major residential end uses of electricity including space cooling, refrigeration, lighting, cooking, water heating and other appliances. The highest potential savings came from increasing the energy efficiency of refrigerators (170 GWh/year) and insulating new Thai residential dwellings and installing more efficient but smaller capacity air conditioners (148 GWh/year) (Parker 1991).

The National Assembly of Thailand passed the Energy Conservation Promotion Act in February 1992; it gives the Department of Energy Affairs (DEA) the power to issue an energy code for new buildings. Initially, the code was voluntary, and developers of new buildings were encouraged to abide by it. Later on the law established stipulations that were binding. The first stipulation was the code on minimum performance levels for the insulating properties of building materials and glazing and recommended levels of lighting and energy intensity. Secondly, was the clause that requires the owners of large buildings and factories to appoint an energy conservation manager and submit a comprehensive energy management plan to DEA. Thirdly, through this Act the DEA established minimum efficiency standards for electricity appliances and energy-consuming equipment. These standards are co-ordinated with the efforts of the Thailand DSM office to set minimum energy efficiency requirements for its various programmes. Finally, the law established the Energy Conservation Promotion Fund, to provide funds for end-use efficiency in Thailand for all sectors and fuel types (Du Point *et al* n.d).

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2 GEF was established as a joint international effort to provide financing for the incremental costs of projects with global environmental benefits.

The Thai DSM programme is considered to be one of the government's most successful programmes. Most acclaimed are the projects promoting efficient lighting, refrigeration, and thermal efficiency in the residential, commercial and industrial sectors. Successful implementation techniques included voluntary agreements with manufacturers, nation-wide advertising campaigns, interest-free loans, and appliance labelling and market transformation. From 1992 to 1996, the direct result of DSM programmes was a reduction of peak demand by 398 MW and 500 000 tons of CO_2 avoided (Clark 1999).

2.7.4 DSM in Brazil

In Brazil the National Electricity Conservation Programme (PROCEL), was set up in 1985. PROCEL produced several conservation scenarios to assess the DSM potential for Brazil and set a target of 130TWh annual savings to be achieved in 2015. The pgrogramme involved use of implementing a combination of DSM measures including information programmes legislative, regulatory, financing, load management, marketing and training activities. As a result in 1993 a 200MW cut from evening peak load, and 294 GWh savings in 1994 were achieved (Boyle 1996). PROCEL also operated a direct installation programme to replace incandescent streetlights with mercury vapour and high-pressure sodium lamps. PROCEL and the distribution utilities that stand to benefit from reducing the arrears of defaulting townships jointly fund the programme (Nadel et al n.d).

In an effort to promote energy efficiency, Brazil set minimum efficiency levels for refrigerators through a process of consultation between manufacturers and government. The agreements involved setting and monitoring efficiency standards. For example the proposed agreements called for efficiency improvements of 5% per annum from 1994 to 1998, resulting in 1998 models consuming half as much electricity as those sold in 1990 (Simmonds 1995). However, currently Brazil has no regulations requiring the adoption of energy efficiency standards, nor are there building codes demonstrating good building practices. Even though provision for energy efficiency was made in the privatisation legislation, some energy efficiency activities have been suspended or terminated. Furthermore a clause in the privatisation legislation requiring utilities to set aside 0.25% of annual utility revenue for investment in energy efficiency projects has not yet materialised (Clark 1999).

2.7.5 DSM in African countries: Zimbabwe and Ghana

DSM experience in Africa is limited. Examples of countries that have adopted DSM are Zimbabwe and Ghana. Like the entire SADC member states, Zimbabwe's energy needs have historically been met by expanding the supply base with little attention paid to efficiency of energy use (ERI 1997; UCCEE 1997). This approach raised financial, institutional and environmental problems. It was acknowledged that these problems could be solved by devising strategies for improving the efficiency with which energy was currently produced and used, and the adoption of approaches to manage environmental impacts of the energy sector (UCCEE 1997).

In an effort to address the issues of energy efficiency in the economy, the government through the Ministry of Transport and Energy commissioned the Zimbabwe Energy Efficiency Project (ZEEP). The first phase of the project was meant to identify potential options for conservation that could lead to viable investments in energy conservation. The project was instituted within a context of rising electricity tariffs and shortage of electrical energy capacity. The Rockefeller Foundation funded the project through the International Energy Initiative. The major players identified for the project were the Zimbabwe Electricity Supply Authority (ZESA), the Department of Energy in the Ministry of Transport and Energy, and private consultants. Perceived benefits from the project were the reduction in expenditure on investments for energy and reduced utilisation of fuels. The environmental benefits were also recognised, but the opportunity to redirect the saved funds to other development activities was a priority for government. The ZEEP identified some options for energy conservation in industry, and issues of end-use efficiency in the domestic sector. The tasks analysed included the potential for improvement in electric water heaters, refrigerators, lighting and electric motors in industry (UCCEE 1997). The ZEEP studies identified a significant potential for efficiency improvements in industry. A number of donor countries have supported industrial energy efficiency initiatives in Zimbabwe, particularly focusing on training of personnel (Boyle 1996). Zimbabwe participated in the Southern African Development Community (SADC) Industrial Energy Management Training project which was originally developed by the Canadian International Development Agency to provide a broad range of energy efficiency services to key industrial sub-sectors in the twelve-country SADC region (ERI 1997). Despite these efforts Zimbabwe is still facing a major energy crisis, and has huge debts owing to the South African utility Eskom for supplying it with electricity.

In Ghana, the development of the energy sector was concentrated in the hands of the government through state-owned energy enterprises, which focused their activities on the supply of energy. Consequently, energy efficiency did not receive much attention until 1995, when the government reformed the energy sector by introducing competition to encourage private sector participation in the supply and distribution of energy (Clark 1999). The government introduced two Acts of Parliament to encourage development of the energy private sector. In line with the government policy of encouraging the private sector and building local capacity in the private sector, the Ministry of Mines and Energy collaborated with private sector partners to execute energy efficiency projects on its behalf.

The Ministry of Mines and Energy with the Private Enterprise Foundation, established the Energy Foundation with a mandate to undertake DSM activities. These include activities aimed at educating the public on measures that can be used to improve the efficiency of energy use at the national level. Some of the activities include national level workshops on energy efficiency in industry, commerce, buildings and domestic appliances. Others include load management in industrial zones; site visits to advise on electrical load management and other energy-related issues; monitoring and targeting energy management in industry; and public education campaigns to educate the public in methods and technologies that can be used to reduce energy waste (Clark 1999). The Ministry has transferred its role in the promotion and execution of energy efficiency programmes to the Energy Foundation so that the Ministry can concentrate on policy formulation activities (Clark 1999).

2.8 Conclusion

This chapter has provided an overview of theory and practice of DSM, particularly energy efficiency, and why and how energy efficiency initiatives are implemented. Energy efficiency is a major component of DSM. There are technologies that can be installed to improve thermal improvements of buildings and efficiency improvements in appliances. Technologies that improve thermal efficiency in low-cost housing and energy efficiency in residential lighting are commonly used because they decrease the energy burden of low-income households. Various energy efficiency programmes can be implemented to promote the adoption of these technologies. These programmes differ in terms of strategies employed and the incentives used. Governments implement some while others are implemented by utilities. To encourage customer participation, some financial incentives are required which could range from free distributions to certain percentage reductions in selling price.

Country motivations to carry out DSM are influenced by the economic, political and socio-economic status of the end-users. Experience shows that many countries have been strongly motivated to implement DSM to defer building of power stations and as an environmental protection strategy. Despite these motivations DSM has not been implemented successfully because of many barriers. Most of these barriers relate to implementation of energy efficiency oriented DSM and not necessarily to load management. Therefore the most serious and prominent barriers are those that prevent optimal investment in energy efficiency.

Country experiences on energy efficiency implementation show that energy efficiency programmes were implemented to capture the potential end-use energy efficiency improvements in the industrial, commercial and domestic sectors. In the domestic sector, energy efficiency programmes were geared towards improvements in appliance efficiency and thermal performance of houses. Lighting efficiency measures were commonly implemented because they have large potential cost-effective gains and because lighting drives a large share of peak electricity demand. Several techniques were used to implement these programmes with varying degrees of success. Evaluations of information programme show that these programmes alone were generally insufficient to stimulate significant changes in technology. However, information programmes are important as a starting point because they can complement and amplify other programmes. If communities are well informed about energy efficiency and its benefits, they can influence investment in energy efficiency at government, utility and customer levels. For example, in industrialised countries such as the US and UK, experience shows that customers and environmentalist groups influenced investments in energy efficiency programmes because they were well informed about it. This means that educational or information dissemination programmes are vital in promoting energy efficiency, even though these programmes may not necessarily provide results in the short term. Loan programmes were also found to be less successful because customers were unwilling to take on debt in order to save energy.

Regulators mandated utilities to implement IRP with commitments to acquire DSM resources. The IRP-DSM linkage was strong in the vertically integrated electricity industry before the introduction of competition. With the introduction of competition in the electricity industry, there are mixed experiences in the implementation of IRP by utilities. Most Public Utility Commissions have suspended their IRP requirements and many are preoccupied with the details of restructuring and do not concern themselves with IRP; as a result some utilities have reduced their DSM efforts and spending. However there are a few countries which continue to require IRP for their utilities because they believe that IRP is in the public interest and has continued importance.

Energy efficiency can also be promoted through direct involvement of government, whereby the government passes legislation for promotion of energy efficiency or finances an energy efficiency programme. Legislation such as energy performance standards has been primarily used in developing countries and has achieved good results. The developing country experience shows that energy efficiency is successful when being driven by government. It also shows that funding to implement energy efficiency is obtainable from international funding institutions. This means that lack of funds should not be an issue that prevents implementation of energy efficiency because there are institutions that are willing to provide such funding. Utilities in different countries promoted energy efficiency by directly investing in energy efficiency. They offered rebates and informational programmes, direct installation, rebates and leasing programmes to encourage customer participation in energy efficiency. Whilst these techniques produced good results they have been applicable in vertically integrated utilities.

3. Implications of the structure and regulation of the electricity distribution industry for energy efficiency

3.1 Introduction

This chapter focuses on two issues: firstly the electricity distribution industry (EDI) structure and its implications for energy efficiency within the current and proposed structure of the distribution sector; and, secondly, the regulation of energy efficiency in the EDI.

Electricity industry restructuring involves changes in ownership and market structure. In South Africa the broader restructuring plan will begin with the restructuring of the EDI. At the moment the South African electricity supply industry (ESI) is vertically integrated and is publicly owned. This ownership and structure of the ESI is about to be changed. It is not clear how this suggested change would affect energy efficiency but there are concerns that the suggested changes will negatively affect implementation of energy efficiency if regulatory measures are not introduced.

The first section in this chapter describes the characteristics of the current EDI structure, DSM motivations, strategies and barriers in the EDI, and the status quo regarding regulation of energy efficiency in the EDI. The second section describes the characteristics of the proposed EDI structure and how this impacts energy efficiency.

3.2 Characteristics of the current electricity distribution industry structure

The EDI is part of the whole ESI structure, which comprises four activities: generation, distribution, transmission and retailing. Brennan *et al* (1996) describe these activities as follows:

- Generation is the process used to create electricity.
- Transmission is the process of conducting the flow of electricity at high voltages from the points of generation to the locations of groups of electricity users.
- Distribution of electricity is the process of transforming high-voltage electricity to lower voltages and then delivering it to households and other users.
- Retail sale of electricity is the process of marketing electricity to the ultimate customers.

In South Africa at the moment Eskom dominates generation, transmission and distribution sections of the electricity industry, which means these sectors, are not subject to competition. Figure 3-1 illustrates the current ESI structure.

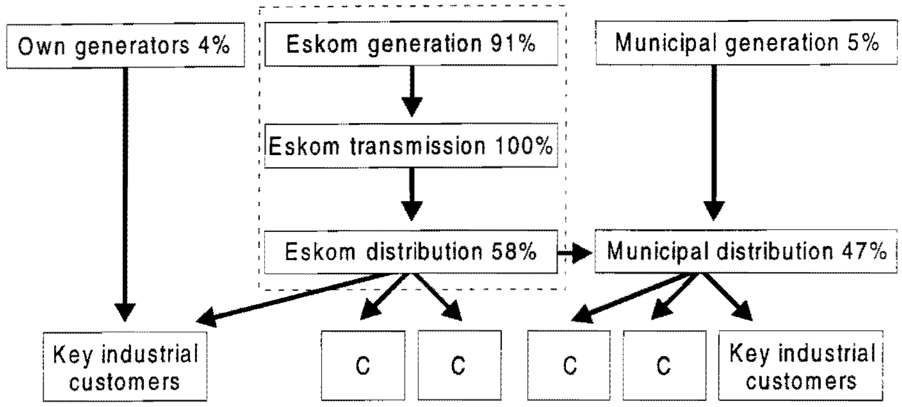

Figure 3-1: The current ESI structure

Source: Barberton (1999)

Figure 3-1 shows that the electricity supply industry in South Africa is still vertically integrated. Eskom Generation produces approximately 91% of electricity for resale in South Africa. Municipal generation produces 5% and key industrial customers (KICs) produce the rest with their own generators (Davis 1999). There are seven municipalities that are capable of generating electricity for distribution to their customers (Barberton 1999). There are also KICs such as Mossgas and other mining industries that generate electricity for their own use. Transmission of electricity is carried out by Eskom Transmission, which is responsible for transmission of electricity from power stations to distribution nodes in all parts of the country. Figure 3-1 also shows that the EDI includes Eskom's Distribution division and a large number of municipal distributors. All municipal distributors and some KICs purchase electricity from Eskom Distribution. Municipal distribution serves some KICs and small customers. The number of customers and electricity supplied by Eskom and others are shown in Table 3-1

Table 3-1: Electricity distribution statistics, 1998

Source: Eskom (1998)

	Eskom distribution	*Non-Eskom distribution*	*Total*	*Eskom as % of total*	*Municipality as % of total*
Number of customers	2.6 mill	3.4 mill	6.0 mill	43%	57%
Energy sales to end-users (GWh)	102,788	74 207	176 995	58%	42%

Table 3-1 shows that Eskom's distribution group supplies electricity to 43% of customers, accounting for 57% of total sales volume. Municipalities collectively serve about 56% of customers and distribute 42% of the electricity supplied to end-users. Although Eskom Distribution has a smaller number of customers than municipalities, it has higher energy sales than municipalities, because it serves the biggest customers. This has contributed to Eskom Distribution's healthy financial position. In the past, Eskom had a relatively small distribution division, focusing on the supply of power to large industrial users and municipalities. In the 1990s Eskom's distribution activities have grown, primarily due to initiation of the electrification programme and Eskom's take-over of a number of utilities in the former homelands (Davis 1999).

Municipal distributors serve customers in areas under their jurisdiction and they vary greatly in size, geographic spread, customer density and base and managerial capacity (Barberton 1999). Each distributor is required to obtain a licence from the National Electricity Regulator (NER). Licence conditions include a requirement that the distributor fulfil an electrification programme (Davis 1999). Most municipal distributors face serious operational and finance problems and are in a weak financial position to raise capital (Praetorius *et al* 1998). The NER reports that there are at least 150 municipalities that are at financial risk, owing to their activities in the distribution of electricity, with most supplying electricity at a loss (NER 1999). These are basically smaller municipalities that have smaller revenue bases and are unable to capture the economies of scale that exist in the distribution industry, pushing their cost structures up. Many of these municipalities have been unable to pay Eskom bulk accounts, necessitating intervention by the NER. Wealthier municipalities are predominantly in metropolitan centres. They are efficient and able to charge high mark-ups and generate large surpluses on electricity sales and therefore able to provide other services without financial strain (Kesswell-Burns 1998).

There are different tariff structures operating in the EDI. Eskom offers a wide range of tariff structures. These include time-of-use tariffs, interruptible supplies, inclining block and a variety of straight line, two-part and three-part tariffs[3] (Davis 1999). However, Eskom Distribution does not get the benefit of different tariff structures when purchasing electricity from Eskom Generation (Swannevelder 1999; Barberton 1999).

Municipalities tend to offer a more restricted set of tariffs, focusing on three-part tariffs for large users and two-part and straight-line tariffs for smaller users (Davis 1999). Price levels also vary across the country, and smaller distributors charge higher prices while larger distributors are charging lower prices. Economies of scale are mainly a result of reduced power purchase costs with increasing size, economies of scale in other distribution costs and smaller financial transfers per kWh sold to cover other municipal expenses (Davis 1999).

The characteristics of the EDI can be summarised as follows:

- Eskom Distribution is dominant, and most customers, in particular municipalities, purchase electricity from Eskom.
- Eskom Distribution purchases electricity from Eskom Transmission and does not receive incentives based on tariff structures.
- Both Eskom and municipalities are retailers of electricity and depend on revenue and margins from electricity sales in order to remain financially viable.
- Licence conditions require distributors to meet electrification targets, necessitating substantial capital expenditure.
- A wide variety of tariff structures are utilised.

It is inevitable that these characteristics will affect implementation of DSM. The following section examines DSM motivation, strategies and barriers prevalent in the current EDI.

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3 See appendix 3 for a detailed explanation of these tariffs.

3.3 DSM activities in the current electricity distribution structure

3.3.1 DSM in Eskom Distribution

3.3.1.1 Eskom's DSM motivation

Top management in Eskom mandates Eskom Distribution Group to implement DSM on the basis that Eskom Distribution Group has closest contact with municipalities and customers (Swannevelder 1999). As a result, only Eskom Distribution Group pays for implementation of DSM programmes. Eskom Distribution Group argues that Eskom Generation Group should contribute towards DSM cost since they are the major beneficiaries of DSM helping to defer investment in new installed capacity. Generation's argument for not paying for DSM is that it is too far removed from customers. Generation also argues that the wholesale electricity tariff (WET)[4] will provide an incentive for distributors to undertake DSM where it is economically viable to do so. However Eskom's motivation to implement DSM, particularly energy efficiency, became clear in 1997 when an efficient lighting working group was constituted within Eskom which would oversee the establishment of an efficient lighting programme or efficient lighting initiative (ELI) in South Africa. ELI has two objectives which are first to contribute towards reduction in peak power demand in South Africa and second to contribute towards reduction in greenhouse gas emissions in South Africa (Clark 2000).

3.3.1.2 Eskom's DSM strategies

In Eskom, integrated electricity planning (IEP) drives Eskom's DSM investment. Eskom defines IEP as the process that selects, from a full array of demand and supply-side options, the least cost combination of actions, risks and investments, which:

- satisfies customer's electricity needs in terms of quantity and quality of supply;
- achieves optimal value for customers;
- is financially viable for Eskom;
- is compatible with Eskom's strategic direction.

The present IEP, called IEP7, includes the following DSM alternatives (Eskom 1998).

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[4] *WET also* known as the bulk tariff, is the price at which generators sell electricity to distributors or large customers.

Strategic load growth

Within the period 1998-2002 Eskom plans to pursue strategic load growth to achieve sales of 15000 GWh per annum while sufficient surplus generating capacity exists.

Load shifting

Eskom has embarked on developing and piloting DSM programmes focused on load shifting primarily within the residential sector. Load shifting will be achieved through the application of Eskom time-of-use (TOU) tariffs, real-time pricing and residential load management. Consequently Eskom management board approved a strategy to implement a long-term peak reduction target of 1600 MW between 1996 and 2015. In addition, Eskom has an interruptible load agreement with its customers, whereby Eskom is allowed to interrupt the power supplied to a portion of the customer's premises for a limited period of time in return for compensation. Eskom will use negotiated contracts and interruptible tariffs to achieve a target of 2900 MW by the year 2005. These measures are only applicable to large commercial industrial and municipality customers, and are not yet extended to residential customers.

Energy efficiency

Within Eskom, energy efficiency is regarded as a customer retention and competition management strategy. A strategy to obtain a reduction in demand of 2500 MW by 2015 through the implementation of an energy efficiency programme was approved in IEP5. IEP7 considers residential, commercial and industrial energy efficiency options.

According to Eskom (1998), residential energy efficiency options included in IEP7 are:

- efficient lighting initiatives (781 MW) electricity savings;
- controlled system hot water conservation (76 MW);
- cooking awareness in new homes (197 MW) ;
- energy efficient fridges and freezers (54 MW) ;
- hot water system insulation (10 MW).

IEP7 recommends that Eskom commit resources to implement cooking awareness and use of compact fluorescent lights (CFLs) in new homes. As a result, Eskom has recently approved implementation of energy efficient lighting (EEL), which involves dissemination of CFLs. A total of R60 million is allocated to implement this programme, Eskom has committed R45 million with R15 million additional funding from the Global Environmental

Facility (GEF) (Eskom 1999). The programme will be phased in over a fifteen-year period from 2002 and will focus initially on the residential segment due to the significant contribution of households to the system peak demand.

Commercial energy efficiency options evaluated by IEP7 include process heating efficiency, HVAC system efficiency and lighting sytem efficiency. Industrial energy efficiency options evaluated by IEP7 include heating, lighting, cooling, fan and compressor, materials handling, manufacturing and pumping system efficiencies. However, these have not been included in the plan yet. In addition, IEP7 recommends that Eskom should make electricity prices in the residential sector more reflective of the true cost of supply to ensure that revenue impact does not exceed avoided resource costs. Each Eskom Distribution Group is expected to undertake the above mentioned DSM strategies. Despite the existence of the IEP and its extensive DSM plan, Eskom's investment in DSM to date has been small.

3.3.2 Barriers inhibiting Eskom Distribution investment in DSM[5]

Tariff structures discourage DSM investment

Eskom Distribution does not receive the benefit of TOU tariff structures when buying power from Eskom's internal pool. This means Eskom Distribution does not benefit by shifting its customers to off-peak and thus cannot minimise the cost of its electricity purchases, and maximise revenue from selling electricity to end-users. Therefore, if it were not for management's directives, Eskom Distribution would not be interested in DSM, or would implement it only if it yields financial returns given internal Eskom transfer prices.

Ring-fencing of Eskom's business units discourages energy efficiency investment

Eskom has not traditionally invested in DSM because of excess capacity, its overall supply-driven approach, and its scepticism about the efficacy of DSM (Clark 1999). In addition, Eskom is ringfencing its business, making Eskom Distribution more concerned about business unit planning, budgeting and profitability. In this scenario it is very difficult to justify an energy efficiency investment programme. Eskom Distribution is the only bearer of energy efficiency cost, and yet does not see itself as the beneficiary of energy efficiency investment. While this would not discourage strategic load growth and load shifting, it discourages energy efficiency.

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5 This analysis of barriers was based on extensive interviews with the Southern Cape Eskom Distribution Group.

Focus on increasing sales and revenue hinders energy efficiency, but not DSM

Eskom Distribution is a retailer of electricity, so its objective is to increase sales and generate enough income to cover costs of its electrification commitments. Since every kWh not sold is a loss in revenue, energy efficiency will be carried out voluntarily only if it has positive financial returns.

3.3.3 DSM initiatives by municipal electricity distributors

Eskom at national level is driving DSM initiatives, so it is easy to understand the direction of DSM in Eskom. The picture is blurred when it comes to municipalities, since each one is individually concerned about its own survival. The following section provides a case study of DSM in the Mossel Bay local authority in the Western Cape. It is possible that some municipalities may have a different perspective from that of Mossel Bay, but this captures key issues.

3.3.3.1 Motivations of Mossel Bay local authority to implement DSM

Mossel Bay local authority is a member of the Southern Cape Karoo Electricity Forum (SCKEF). Municipalities in the Southern Cape Karoo realised that there was a need to improve the effectiveness of electricity distribution in the area. The issue that raised this concern was the need for local authorities to supply electricity at low cost. It was concluded that, in order to fulfil this commitment without increased costs, rationalisation and consolidation of distribution networks and electricity purchase contracts of different local authorities in the region was necessary (Potgieter 1997; Bothma 1999). On 4th September 1995 the SCKEF was established.

Municipalities in the area including Mossel Bay are interested in DSM because of a desire to reduce high electricity purchase costs and their bill with Eskom, and decrease bad debts due to non-payment of electricity (Bothma 1999). Because electricity during peak demand is very expensive it pushes up the electricity purchase costs. The TOU tariffs offered by Eskom Distribution provides Mossel Bay municipality with an incentive to implement DSM to shed peak load in order to minimise costs and maximise profits. They do this by encouraging customers to shift consumption to off-peak periods through the TOU tariffs offered which are offered to industrial and commercial customers at the moment. This allows the municipality to implement only load management type of DSM and not energy efficiency oriented DSM. Therefore the municipality has no motivation and no incentives to invest in energy efficiency.

3.3.3.2 Mossel Bay DSM strategies

Load shifting

Ripple control measures and TOU tariffs are used to shift the electricity demand to reduce peak demand. Ripple control is applied to residential customers, and it involves switching geysers on and off in certain times to reduce demand but not kWh sales. The municipality has installed remote geyser control measures to save on the maximum demand tariff from Eskom. The municipality also offers TOU tariffs to industrial users only, in response to the Megaflex tariff charged by Eskom. Megaflex tariffs are based on TOU– i.e peak, standard and off peak tariffs. Megaflex tariffs allow municipalities to pass benefits to their customers. This benefit is only enjoyed by large commercial and industrial customers and is not yet passed on to residential customers. Residential customers are on maximum demand tariffs and therefore do not enjoy time of use benefits (Bothma 1999).

There are considerations to phase out remote geyser control measure because it is not as profitable as the TOU. Once the municipality obtains enough technical and financial capability to install TOU metering sytems for residential customers, it will phase out geyser control measures (Bothma 1999).

Energy efficiency

Mossel Bay municipality regards energy efficiency as a strategy that will lead to a reduction in sales. Since the municipality generates profits from electricity sales it is not interested in reducing sales. Consequently the municipality has no incentive for efficiency oriented DSM measures since energy efficiency will reduce sales. Instead the municipality only has incentives to implement load shifting to reduce its electricity bill from Eskom and manage peak demand, since Eskom charges a high rate for peak electricity demand (Bothma 1999).

3.3.3.3 Other changes in distribution

Although not strictly DSM measures, there are two recent changes in distribution that affect consumer demand and utility costs. These are municipal consolidation of municipal distribution networks and purchase contracts and installation of prepayment meters in newly electrified households.

Consolidation of distribution networks and electricity purchase contracts

The move by municipalities in the Southern Cape to form the SCKEF has resulted in a consolidated distribution network. By joining together, these municipalities have a more cost-effective way of purchasing electricity. They have a strong bargaining power with Eskom, which enables them to buy bulk electricity at lower cost. According to Barberton (1999), consolidating different municipality demand profiles and customer bases offers scale advantages for DSM even though it is not a DSM measure itself.

Prepayment meters for newly electrified customers

The municipality has installed prepayment meters in newly electrified and low-income households. As a result more customers in Mossel Bay are provided with electricity by means of prepaid meters. Through this system the municipality has cut losses due to electricity theft and non-payment. The loss on sales before installation of pre-paid meters was close to 30%; it dropped to 14% during the first year of installation and subsequently to 3%. The number of customers on prepayment and credit metering systems in Mossel Bay are shown in Table 3-2.

Table 3-2: Number of customers on prepayment and credit metering sytem in Mossel Bay
Source: Bothma (1999)

Type of metering	*No. of customers*	*Gwh*	*c/kWh*	*Income (Rm)*
Prepaid meters	8 321	26	0.3	7 334
Credit meters	5 639	34	0.3	10 203

While use of prepayment meters encourages efficient use of electricity, it also results in decreased electricity consumption. However, net income increases because of more efficient collection since more electricity gets paid for than when credit meters are used. Table 3-3 shows a simple analysis of this outcome based on the assumption that consumption declines by 10% because of prepayment meters.

If we start with an established low-income household with basic electrical appliances consuming 3600 kWh per year, and assume that the installation of a prepayment meter would decrease this consumption by approximately 10%, utility revenue still increases. This is because, with the estimation that 70% of electricity gets paid for before prepayment meters are installed, only 2520 kWh generates income for the utility. After installation of prepayment meters the household will end up paying for 97% of the electricity consumed. This results in a net benefit to the distributor of R185 per year per household.

Table 3-3: Example illustrating the effect of use of prepayment meters on net income of the municipality

	Before installation of prepaid meters	*After installation of prepaid meters*	*Net benefit*
Annual consumption (kWh)	3600	3240	-360
% electricity that gets paid for	0.7	0.97	
kWh that gets paid for	2520	3142	623
Rate c/kWh	0.3	0.3	0.3
Income (R)	756	943	185

3.3.4 Barriers inhibiting municipal investment in energy efficiency

Focus on increasing sales and profitability

The municipality is a retailer of electricity; it has to maximise its income by maximising electricity sales, and is concerned about the loss of revenue from electricity sales. At the same time it has to minimise electricity purchase costs to reduce its Eskom bill by reducing peaking load. This is reinforced by the tariff structures, which allow municipalities to invest in load management in order to minimise the cost of electricity purchases while maximising revenue from selling electricity. In this context the municipality is biased against energy efficiency oriented DSM. Consequently the municipality has no strategy in place to promote energy efficiency among its customers.

Lack of information

Although the municipality is aware of DSM strategies, DSM is still regarded as a direct load control tool, and energy efficiency-oriented DSM is not regarded as suitable. The result is a tremendous loss of energy saving opportunities that could be seized by the municipality. There is also lack of information at customer level. Customers have no information on materials and appliances to help them save on electricity (Bothma 1999).

Cross-subsidisation of other services

Mossel Bay, like all other municipalities, uses income generated from electricity sales to cross-subsidise services such as health care, street cleaning, refuse removal, libraries, clinics, and maintenance of infrastructure. This practice creates a barrier for energy efficiency oriented DSM because it would reduce electricity sales and thus deprive the municipality of the income.

3.3.5 Conclusions on current EDI influences on energy efficiency

Some observations can be made regarding the status of DSM in the current EDI. Both Eskom Distribution and municipal distributors have little incentive to implement energy efficiency. Although Eskom has a DSM plan in place, Eskom Distribution has limited motivation to implement it, simply because, to them, DSM has no financial benefit. If it were not for directives from management, Eskom distribution would not be considering DSM or they would consider only DSM that yields financial returns. This means that energy-efficiency oriented DSM would be left out.

The municipal distributors currently focus on DSM measures that allow them to manage their load profiles so as to reduce their purchase costs with Eskom. Consequently municipal distributors prefer load-shifting type of DSM and not energy efficiency-oriented DSM. The DSM measure adopted by the municipality is directly influenced by the structure of tariffs they get from Eskom Distribution. In other words, the municipal distributor carries out DSM as way of responding to tariff structures.

Another observation is that both Eskom Distribution and the municipal distributor have a direct revenue interest in maximising sales. These distributors have to generate enough income to cover the cost of their electrification programmes. In addition, municipal distributors have to generate surplus from their electricity sales, which they use to subsidise the provision of other services. This is a further obstacle to the implementation of DSM measures aimed at increasing energy efficiency, because these measures would reduce revenue from electricity sales.

The structure of the current EDI and electricity tariffs is more receptive to a load shifting type of DSM, and is biased against DSM aimed at increasing energy efficiency. This shows that some intervention is required to strengthen the promotion of energy efficiency oriented DSM. The following section explores the current regulatory measures to promote DSM in South Africa, in particular energy efficiency oriented DSM.

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3.4 Measures to promote energy efficiency in the current EDI

There are various measures that have been undertaken to promote energy efficiency in the current EDI. Firstly, energy efficiency is included in the recent White Paper on Energy Policy. The White Paper notes that 'since expenditure on energy constitutes a large proportion of the country's GDP (15%) and a particularly large proportion of poor household's expenditure, it is necessary to give attention to the effective and efficient use of energy. Energy efficiency and energy conservation considerations must therefore form part of an overall energy policy'. As a result the White Paper has a section dedicated to energy efficiency in industry and commerce, households, transport and government. In addition, the White Paper commits the government to ensuring that an integrated resource planning approach for large investment decisions by energy suppliers and service providers is undertaken (DME 1998). Secondly the Department of Minerals and Energy is in the process of determining the feasibility of establishing a national Energy Efficiency Agency, which would provide an implementation vehicle for current DSM and other institution's energy efficiency related activities. Consultants commissioned to investigate this issue have delivered a draft business plan. Due to new DME priorities and resource constraints, this initiative has not been carried further forward. It has been suggested that a second, more in-depth study on the feasibility of such an agency be commissioned (Barberton & Clark 1999).

Thirdly, the White Paper on Energy Policy states that government is committed to establish energy efficiency norms and standards for commercial buildings, as well as voluntary guidelines for the thermal performance of low-cost housing. A document with Minimum Norms and Standards on low cost housing is available. These norms and standards are meant to minimise lifecycle costs and provide adequate comfort levels (DOH 1999). Nevertheless, houses are still being built without following these guidelines, although energy efficient demonstration houses, which include these guidelines, are being built by non-governmental organisations. Communities are responding positively to these houses (Karottki & Van Sleight 1999).

Fourthly, the White Paper commits the government to establishing an appliance-labelling programme. To date, a proposal to develop a project on this has been written and introduced to the Energy Branch, and then to the 'Household and Electrical Products Division' of the Department of Trade and Industry. It is likely though that the DTI will choose to rely on market transformation initiatives undertaken in the international arena to bring about improvements in South Africa (Barberton & Clark 1999).

Fifthly, there are educational initiatives of the National Domestic Energy Efficiency Task Team, which has completed its recommendations for efficient use of energy in households. Local authorities will be able to promote energy efficiency in their areas of jurisdiction by using the recommendations to persuade end users to use energy more efficiently (Barberton & Clark 1999). The government also proposes to include energy efficiency issues in schools' curricula at primary, secondary and tertiary levels. Information materials have been developed to be used as reference material for the Technology 2005 project that was initiated by the Department of Education. This material has been developed to meet the set of requirements for the outcomes-based education system that has been introduced by the Department of Education. Ongoing consultation, at various levels, has been proceeding in order to facilitate the acceptance of the material (Barberton & Clark 1999).

Lastly, is the establishment of the National Electricity Regulator (NER). The NER is responsible for regulating the ESI as a whole and was established before the publication of the Energy Policy White Paper, to implement a new policy of regulation in the electricity industry. Initially the NER did not engage in any energy efficiency measures since it had limited staff (less than twenty professionals) with minimal capacity to widen its scope of regulatory activities to encompass energy efficiency (Van Horen & Simmonds 1998). Instead the NER's focus was on setting regulatory measures that subjected Eskom and municipal distributors to regulatory oversight for the first time (Mammon 1995; Van Horen & Simmonds 1998; Davis 1999). The White Paper states that the NER should require as part of licensing agreements, that investment decisions at generation, transmission and distribution levels should be based on principles of integrated resource planning (IRP) (DME 1998). This requirement will strengthen the status of energy efficiency. Nevertheless this requirement is not applied yet, as there are still problems.

Despite changes at a policy level, very few measures to promote energy efficiency are actually in place in the current EDI, and that is why there is so little energy efficiency activity. For example, even though some of the initiatives such as the guidelines for low cost housing do exist, they are not followed. In addition most of the strategies suggested are still at the planning stage, yet the EDI is about to be changed. This puts these initiatives at risk of being discontinued in new EDI.

3.5 Characteristics of proposed electricity distribution industry structure

3.5.1 The proposed ESI structure

The impact of EDI restructuring on DSM needs to be assessed within the context of broader electricity industry restructuring and the impact this may have on incentives to carry out DSM. The government's White Paper on Energy Policy recommends breaking up of the vertically integrated ESI so that Eskom no longer enjoys a monopoly in the industry. The envisaged structure introduces competition in the wholesale and retail markets in the long run. Wholesale competition entails separating the transmission, generation and distribution sectors in an effort to open up the market so that all generators can sell power to local distributor utilities and other wholesale customers, such as power marketers. Under this scenario electricity users would continue to purchase electricity from local utilities. Retail competition on the other hand entails separation of local distribution from retail sales (Clark 1999).

The South African ESI restructuring process involves introducing competition in the wholesale market before it is introduced in the retail market. However, it is agreed that the first step of the restructuring process should be the rationalisation of the EDI into Regional Electricity Distributors (REDs) (ERIC 1996). In this model Eskom Generation and Transmission are left intact and no independent power generators will be allowed to operate. This is illustrated in Figure 3-2.

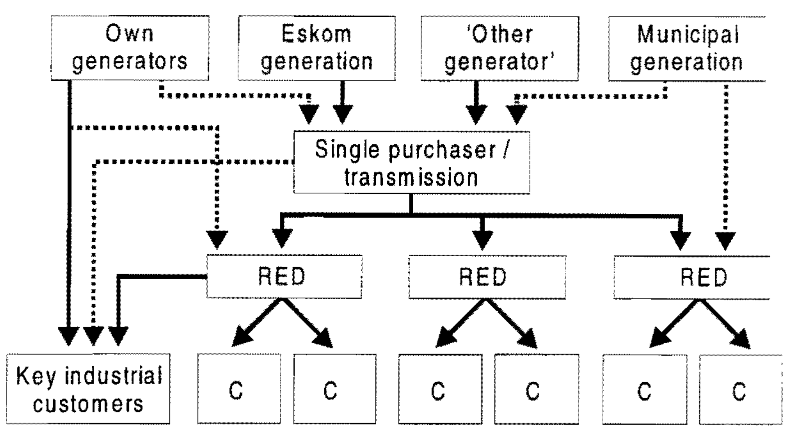

Figure3-2: The proposed first phase of restructuring

Source: Barberton & Clark (1999)

Figure 3-2 shows that the ESI restructuring will start off by changing the structure of the EDI. The EDI restructuring will result in the consolidation of existing Eskom Distribution and municipal distribution into a maximum number of financially viable REDs. REDs will be established to supply customers within their allocated areas based on provisional boundaries. The REDs will purchase their electricity from Eskom Transmission. Generators owned by KICs will supply the KICs and some REDs. It is not yet clear whether the KICs will be allowed to purchase electricity directly from Eskom Transmission. Municipal generators owned by certain municipalities will be allowed to generate electricity and sell it to the transmission grid or directly supply a RED within its area. A RED will directly serve some KICs and small customers such as residential and commercial customers. Since the focus in this research is on the EDI structure, which involves forming REDS, it is important to discuss the REDs model in detail.

3.5.2 The REDs model

The recommendation to establish REDs is stated in the Energy White Paper (DME 1998) on energy policy as follows:

> Government will consolidate the EDI into the maximum number of financially viable REDs. Government will own the REDs. Control of all distribution network assets must pass to the companies and government will determine appropriate mechanisms for achieving this.

The White Paper goes on to state that a transitional structure will be implemented, consisting of Eskom Distribution as well as municipal distributors, and will be a separate company from Eskom Generation and Transmission (DME 1998). The number of REDs is still to be established but it is estimated that five to twelve will be a suitable number (*Business Day* 15 Nov 1999).

The government's decision to replace the distribution system with REDs emanates from the recommendations made by the Electricity Restructuring Interdepartmental Committee (ERIC). ERIC was an internal government committee that was created by an inter-Ministerial committee to formulate government's position on the restructuring of the ESI. ERIC's recommendations were consolidated and submitted to Cabinet in 1996.

In its report ERIC suggests that the immediate crisis in the EDI warrants it being targeted for reform first and that restructuring of the EDI should be done to achieve the following:

- ensure that agreed electrification targets are met;

- provide low-cost electricity;
- facilitate better price equality, with transparent subsidisation where needed;
- improve the financial health of the industry;
- improve the quality of service and supply and be responsive to customer needs and market forces;
- foster proper co-ordination of operations and investment capital, to realise an efficient overall system infrastructure, achieve economies of scale, facilitate co-ordination of operations and facilitate distributor's ability to borrow long-term capital;
- attract and retain competent employees.

Concerning the structure of the EDI, ERIC evaluated five models. These were: a single, vertically integrated generation, transmission and distribution utility; a single national distributor; REDs; splitting the wires business and electricity business; and having a small number of municipal distributors, along with Eskom supplying the rest of the country (ERIC 1996). It was found that all five models would perform better when compared to the current fragmented structure. However the REDs model was found to be the most suitable and appears to have the most benefits (Barberton 1998).

ERIC recommended that five REDs be established based on regional provisional boundaries. These regions are illustrated in Figure 3-3. Figure 3-3 shows that:

- Northern (RED A) comprises most of the Northern Province, Mpumalanga and North West Provinces and the northern portion of Gauteng;
- Western Cape (RED B) comprises all of the Western Cape and a portion of the Northern Cape;
- Central (RED C) comprises all of the Eastern Cape, most of the Northern Cape and the Free State, and a portion of North West Province;
- Eastern (RED D) comprises of all KwaZulu-Natal and the eastern portion of the Free State;
- Wits (RED E) comprises the remainder of Gauteng

According to Van Horen & Thompson (1998) only three of these REDs are able to generate positive financial results. A model termed the Electrification Fnancing Model (EFM) was used to determine financial performance of the REDs. This model included the main input variables, which influence the financial viability of electrification projects, and a number of output variables, which provide an indication of the performance of an electricity distributor.

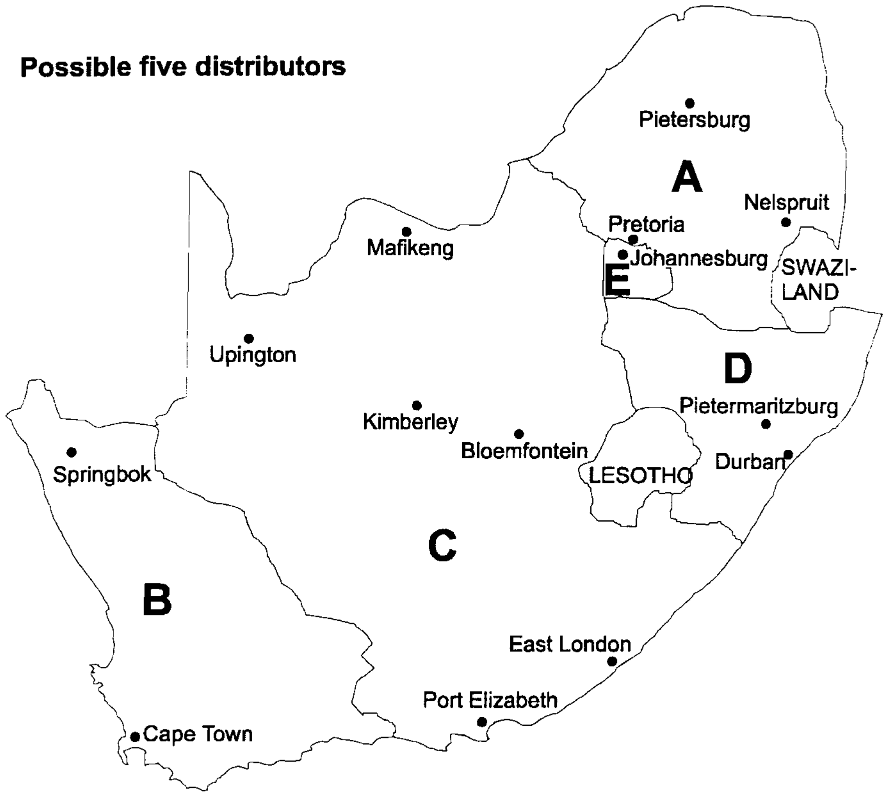

Figure 3-3: Geographic location of possible REDs
Source Davis (1999)

The financial performance of the five REDs in 1997 produced by the EFM is presented in Table 3- 4.

Table 3- 4 Financial results of the five REDs without price increases and subsidies (grid and off-grid) in 1997 (Rm)

Source: adapted from Van Horen and Thompson (1998)

	Northern(A)	*Western(B)*	*Central(C)*	*Eastern(D)*	*Wits(E)*	*Total*
Income statement						
Sales revenue	6488	2271	4447	4911	6291	24408
Operating costs	-5944	-1750	-4153	-4028	-4906	-20781
Municipal transfers	-320	-252	-314	-197	-704	-1787
Operating surplus	224	269	-20	686	681	1840
Interest paid	-270	-35	-164	-98	-59	-626
Net surplus	-46	234	-184	588	622	1214
Balance sheet						
Fixed assets	5290	1053	3072	2660	2038	14113
Liabilities	2440	428	1492	1057	825	6242
Accumulated reserves	2332	471	1386	1135	910	6234
Financial ratios						
Debt /equity[6]	1.0	0.9	1.1	0.9	0.9	1.0
Interest cover[7]	-0.8	-7.7	0.1	-7	-11.5	-2.9
Return on equity[8]	-2%	50%	-13%	52%	68%	19%
Return on sales[9]	3%	12%	-0.5%	14%	11%	8%

These summarised results show that the Western, Eastern and Wits REDs enjoy a favourable financial position. They are able to generate positive operating results after payment of the municipal transfers and a positive net surplus after payment of interest. In addition, these REDs have high interest cover ratios, indicating that there is no financial strain after payment of interest. They have high rates of return on both equity and on sales

6 Debt/equity ratio equals long-term liabilities divided by accumulated reserves

7 Interest cover ratio equals net operating income (before interest divided by interest paid)

8 Return on equity equals net income (after interest) as a percentage of accumulated reserves.

9 Return on sales equals net operating income (before interest) as a percentage of total sales revenue.

indicating a favourable financial position for a number of years. The financial viability of these REDs depends on the level of consumption, which determines the sales revenue. These financially healthy REDs generate positive financial operations because they have higher consumption levels. They serve large and wealthy consumers with substantial consumption levels.

The two weaker REDs, the Northern and the Central, are not able to generate positive operating results. They cannot generate positive returns, nor cover interest payments. In addition, both REDs have a negative return on equity. The Northern RED has a very low return on sales, whilst the Central RED has a negative return on sales. They are financially unviable without a price increase and external subsidy because they mainly serve a large number of poor consumers who consume smaller amounts of electricity. When consumption is low the sales revenue does not fully cover all costs such as electricity purchase costs and capital costs. All REDs depend on electricity sales in order to make profit. Projects that will reduce consumption may make them less financially viable. Unless the dependence of distributors' profit making on electricity sales is reduced, distributors will prefer types of DSM that do not interfere with the level of consumption.

Despite the projected financial position of the REDs, the fewer distributors are likely to be financially stronger than the sum of existing Eskom and municipal distributors, for two reasons. Firstly, they can realise significant scale economies, which will result in operational cost savings. Secondly, they will not be required to subsidise the provision of other municipal services directly (Barberton & Clark 1999).

It is inevitable that the above-mentioned characteristics of the REDs scenario will affect the implementation of DSM, although it is not yet known for certain, because the restructuring process has not begun yet. The prospects of DSM are explored in the following section.

3.6 Eskom and municipal perspectives on the new EDI structure

Municipal distributors and Eskom Distribution, as stakeholders in the proposed REDs, will influence the direction of DSM in the new EDI structure. It is thus important to get the views of these stakeholders on their motivation to implement DSM and strategies that are likely to be implemented.

3.6.1 Motivations to do DSM

Currently, management at national level instructs Eskom Distribution to carry out DSM for the benefit of Eskom Generation. In the REDs scenario it is expected that REDs will be in a position to implement DSM for their own benefit. Basically, REDs will undertake DSM to save on distribution network infrastructure. At the moment Eskom Generation benefits from DSM activities because they help in smoothing the generation load profile so as to prevent the need for new power stations. Although the DSM measures also enable Eskom Distribution to save on network infrastructure on a local level, these savings are not substantial, because the national generation benefits are not being carried through to distribution level. If there are no financial incentives provided in the new scenario, the REDs will not be interested in energy efficiency. However, it is hoped that when Eskom Distribution, Transmission and Generation are split up in the new ESI, tariffs that include incentives at the two interfaces will be used to overcome this barrier. However this will make it possible for the new REDs to implement load management DSM but probably not energy efficiency (Swannevelder 1999). The municipality's view is that in a new EDI, DSM will be carried out to reduce purchase costs and bad debts due to non-payment of electricity. It is interesting that they do not see energy services as a way to add more value and hence make more profit.

3.6.2 Future DSM strategies

Because the RED will be interested in managing its electricity load and maximising electricity sales, load shifting strategies will be more suitable DSM strategies to implement. This is because these strategies have a possibility of generating revenues that will enable the RED to recoup the costs incurred within 12 to 18 months (Swannevelder 1999, Bothma 1999). Technologies; such as geyser thermostat control and timers that switch off geysers during peak times could be considered. It is possible TOU will be extended to residential customers. REDs are unlikely to promote energy efficiency as long as the their profits are dependent on electricity sales.

3.7 Barriers that will inhibit REDs investment in energy efficiency

Since it is not clear how the REDs will operate it is not possible to be sure about the barriers that will inhibit their investment in energy efficiency. These barriers mentioned here are possible barriers and are influenced by the perspectives of distributors on energy efficiency in the future EDI and by what is currently taking place in the EDI and as the EDI is being prepared for restructuring.

Focus on increasing sales and profitability

REDs as retailers of electricity will focus on making profits from sales of electricity. This will serve as a barrier against energy efficiency investments, because investment in energy efficiency projects would decrease electricity consumption and sales. Inevitably, REDs will invest in a range of measures aimed at increasing revenues. However it is likely that only investments in DSM measures aimed at improving load management and encouraging strategic growth in demand will feature strongly among such investments.

Emphasis on low electricity prices

It is difficult to achieve energy efficiency in an environment where energy prices are low. In South Africa the electricity costs do not include the external costs that are generated in power production, distribution and consumption, and therefore do not reflect full social costs. Prices do not even include marginal financial costs. The emphasis in the White Paper on cost reflective prices does not mean setting prices based on marginal costs. Instead this cost reflectivity only means the elimination of cross-subsidised services, which will reduce prices for high voltage supplies (*Cape Times* August 1999). Furthermore, distributors do not pay Transmission the full cost, and this is likely to continue even when the REDs are in place. In this situation the REDs would use low prices as a marketing tool to increase consumption of electricity so as to raise revenues and profit. This will make it difficult to convince these distributors to change from their perspective of selling kWh to selling of energy services.

Distributors have no capacity to implement IRP

Distributors, especially municipalities, do not understand the rationale for the IRP and are not well equipped to implement it. This implies that, possibly, distributors in the end will not do IRP.

Customers lack information and perceive energy efficiency investments as risky

Customers' lack of, or imperfect, information and understanding of energy efficiency oriented DSM is another variable that will contribute to distributors not promoting energy efficiency. Eskom's market research shows that current awareness about energy efficiency is low across all income segments in South Africa (Eskom 1999). This condition is likely to persist if no measures are taken to rectify it. Because of lack of awareness on energy efficiency, customers regard energy efficiency investments as risky. As a result it will be difficult for REDs to convince customers to participate in energy efficiency which means that the REDs will have to provide some very attractive financial incentives to customers which would be costly to the distributor.

Lack of suitable legislative and regulatory mechanisms that promote energy efficiency

Although the White Paper on Energy Policy has policy objectives on energy efficiency, they contradict policy objectives on maintaining low electricity prices. The White Paper gives priority to energy efficiency, whilst simultaneously putting emphasis on low electricity prices. Low electricity prices are a disincentive to energy efficiency and thus it will be difficult to achieve energy efficiency initiatives in an environment where electricity prices do not reflect the cost of delivering electricity. The NER is further overloaded with tasks of rationalising tariff structures and setting retail prices. Under these circumstances the NER's capacity to prioritise energy efficiency concerns will decrease, with the implication that for some time the progress of energy efficiency in South Africa could be sidelined.

Regulatory measures that are being proposed are too general and will not address promotion of energy efficiency. Particularly, these measures are insufficient to provide incentives to distributors to invest in energy efficiency measures. In addition the NER has insufficient human resources, which will negatively affect its ability to carry out IRP (Ellman 1999b). IRP is complex and requires special skills and large amounts of highly accurate data, which is difficult and expensive to obtain.

In summary, the future of DSM depends on it being seen as a profitable investment by the REDs. It is clear that REDs will not automatically invest in DSM unless it yields some financial benefits. This will create a bias against energy efficiency strategies, since these strategies reduce profitability if the utility depends on electricity sales. This means that market forces alone cannot be left to determine the fate of energy efficiency oriented DSM in this country. There is a need for regulatory mechanisms to encourage the promotion of DSM. In the following section prospects for regulating the EDI to promote energy efficiency are discussed.

3.8 Regulatory measures that are likely to be used to promote energy efficiency in the new EDI

The Energy Policy White Paper states that each generator, transmitter and distributor should do IRP (DME 1998). Amongst other things, IRP involves examining and analysing all options on the customer's side of the meter (i.e. DSM options) for modifying demand profiles. In addition IRP is a useful tool to improve efficiency of energy usage and to reduce national energy intensity and to improve asset utilisation, profitability and sustainability of operations in the ESI. IRP also helps to minimise the cost of energy services (Ellman 1999a). DSM and energy efficiency are components of IRP.

The NER is mandated by government to oversee the implementation of IRP throughout the industry and to issue guidelines for its implementation. To give effect to requirement for IRP, the NER will apply IRP as a regulatory tool whereby ESI players will be required to implement IRP in order to get a license to do business (Ellman 1999a). In order to implement IRP successfully, the NER should have clarity on capacity and skills available, costs of implementation and responsibilities of role players, monitoring and evaluation of implementation, auditing of input data and results (Ellman 1999a). Because of these concerns, the NER has invited ESI stakeholders to draw policies and guidelines for IRP implementation. As a result of this collaboration an IRP Working Group has been established to facilitate the successful implementation of IRP (Ellman & Alberts 1999).

The Working Group identified four broad issues that should be dealt with to ensure successful implementation of IRP and established four task teams to tackle them. The first is the IRP objective task team, which is responsible for defining the objectives of the IRP at each level and listing of the questions that IRP should address at each level. The second is the IRP planning process task team, which should establish the process for developing IRPs at regional, national and local level, and consider how the plans will be integrated and-co-ordinated to optimise the use of resources. The third is the IRP data and modelling task team with a responsibility to define the data input, data sources and common data required for IRP modelling at the various levels of IRP. The fourth is the IRP implementation task team, which is responsible for developing an implementation programme considering training, pilot projects, phasing in of licensing requirement and setting time frames. These task teams have not met and no discussion has taken place yet (Afrene-Okese 2000).

3.9 Conclusion

The characteristics of the EDI structure affect the implementation of DSM in South Africa. Currently, Eskom Distribution Group dominates the distribution industry, which is part of a vertically integrated electricity supply utility. Because of this situation no sector of the industry is willing to be responsible for DSM. Although Eskom Distribution is in a unique position to implement DSM because of its proximity to customers, it is not given the necessary financial support by top management. Distributors, as retailers of electricity, depend on revenue derived from electricity sales and are more interested in investing in load management and load shifting types of DSM. They are reluctant to invest in energy efficiency, since it reduces electricity demand and revenue from electricity sales. Therefore, distributors would invest in energy efficiency if financial incentives are provided. This situation is likely to be perpetuated in the proposed EDI structure if no financial incentives are provided to distributors to encourage investment in energy efficiency. Another barrier that inhibits investment in energy efficiency is conflict in policy proposals in the promotion of energy efficiency. Conflict in policy proposals is indicated by the emphasis of the government and the NER on low electricity prices whilst simultaneously being willing to promote energy efficiency. Although the White Paper on Energy Policy has documented policy objectives on implementation of DSM and promotion of energy efficiency, there are no appropriate policy strategies to achieve these objectives. The NER has not yet spelled out the regulatory measures that will be used to promote energy efficiency. This affects promotion of energy efficiency now and is likely to affect its survival in the future. It is also a concern that, since some of the energy efficiency initiatives are still at a planning stage in the current EDI, it is not clear whether these will be pursued and valued in the new EDI.

However, some of the barriers inhibiting energy efficiency are likely to be removed by EDI restructuring. Municipalities, for example, will no longer be cross-subsidising other services with revenues from electricity. REDs are likely to be larger and have more capacity than existing distributors. They will therefore be in a better position to evaluate the financial viability of DSM investments, and given their narrow focus on electricity will face fewer competing priorities.

4. Financial impact of energy efficiency interventions on financial position of the RED

4.1 Introduction

The aim of this chapter is to analyse the investments in energy efficiency from the distributor's perspective. The analysis involves showing the effect of energy efficiency investments on the financial position of the proposed Western RED. As the Western RED is one of the financially viable REDs, this analysis tests how viable it will remain if energy efficiency projects are included. The energy efficiency case studies examined are energy efficient lighting and thermal improvements to RDP housing. According to Spalding-Fecher *et al* (1999), these interventions could benefit both the consumer and society, and would mitigate growth in electricity consumption while providing equivalent or superior energy services to low-income households.

There are three sections that make up this chapter. The first section describes the energy efficiency interventions chosen. The second describes the methodology and assumptions used in the analysis. The third section presents the results of the analysis.

4.2 Energy efficiency interventions

4.2.1 Energy efficient lighting for low income households

Lighting generally contributes a relatively small portion to the base load but a large part of the peak load. Eskom is concerned about electricity use for lighting because peak use for lighting coincides with peaks for cooking, space heating and water heating. This increases expensive peak load requirements. Eskom has therefore considered using CFLs, which use significantly less power than conventional incandescent bulbs, to reduce the lighting load. CFLs are 80% more energy efficient and last eight to ten times longer than standard incandescent lamps (Scholand & Tubeni-Ndzube 1999).

The promotion of, and investment in, energy efficient lighting could simultaneously benefit consumers and distributors. In South Africa lighting makes up to 80% of the electricity bill in newly electrified low-income households (Bredenkamp 1998). This is particularly true where households do not have hot water geysers and do not cook extensively with electricity. This provides a unique opportunity to initiate these customers in the practice of using electricity for lighting efficiently, and help in reducing their electricity bills. From the utility's perspective, energy efficient bulbs can have significant impact on peak demand.

4.2.2 Thermally efficient low cost housing

Like the CFL technology, installation of a ceiling and other low cost options to promote thermal efficiency are cost-effective measures that could reduce energy consumption. The provision of a ceiling is a simple and yet critical measure for improving the thermal performance of dwellings by creating a physical barrier between the attic and living space.

The housing delivery programme of the government presents a unique opportunity to incorporate energy and environmental issues associated with the dwellings (Scholand & Tubeni-Ndzube 1999). Homes built to date through the government's RDP do not incorporate energy efficient design measures, often resulting in homes only marginally better in terms of energy consumption, emission reduction and habitability than the shacks they are replacing (Van Horen *et al* 1998; DOH 1999). Less than 20% of these homes include a ceiling, and a negligible few percent have made provision for insulation (IIEC 1997).

There is a risk that these issues will continue to be left out if the emphasis on speeding housing delivery to meet political targets is not changed. If houses are not thermally efficient, they will overheat in summer and become exceedingly cold in winter, requiring excessive energy consumption and household expenditure to maintain comfort. Accordingly, Spalding-Fecher *et al* (1999) note that ceilings and insulation improve comfort levels in both summer and winter, but the impact on energy use will only occur in winter, since most low-income households do not make use of air conditioning or fans. In addition, many households do not rely on electricity for space heating, instead using other fuels such as wood, coal, paraffin and gas is common. For example space-heating needs in the Cape Town area are currently met with paraffin and electricity (Van Horen *et al* 1998). As a result, while households may reap substantial benefits from reduced heating costs, the utility will only experience a small reduction in electricity demand. But heating loads peak in the evening during winter. According to Scholand & Tubeni-Ndzube, (1999) ceilings, with all other parameters held constant, produce a saving of approximately 74% on winter heating needs whilst insulation further enhances the energy savings benefit of the ceiling, to an estimated 90%.

These two energy efficiency interventions are analysed to determine whether they are financially viable investments from the perspective of the RED. The methodology used in the analysis is described below.

4.3 Methodology and assumptions used in analysing the interventions

4.3.1 Revenue impact test

The financial viability of each intervention is tested using the utility revenue impact test. This involves calculating costs and benefits to the utility arising from energy efficiency interventions. These costs and benefits are factored into a cash flow stream for each project and discounted at the utility discount rate to determine the net present value (NPV). Only the net costs and benefits that arise because of investment in the energy efficiency projects are included in the cash flow. The revenue impact test is discussed in Appendix 1. The financial position of the Western RED is adjusted by including the net costs and benefits in its income statement.

4.3.2 Assumptions for analysis

For the purposes of this analysis a number of key general and project specific assumptions have been made. General assumptions include the following:

- The discount rate is the distributor's cost of capital, taken as 15%. The discount rate is then used to discount the cash flow generated by the energy efficiency projects into present monetary values.
- An electricity tariff of 33 c/kWh is used to calculate revenue and lost revenue generated by each energy efficiency intervention.
- Electricity load curves and share of peak electricity use are required to determine the cost of electricity consumption for lighting and space heating needs at different periods such as peak, shoulder and off-peak. Eskom peak times are taken to be from 18:00-20:00 Monday to Friday and the shoulder period is taken as 8:00-10:00 and 20:00-21:00 Monday to Friday. Off peak periods are all other times and all weekends (Spalding-Fecher *et al* 1999). Share of electricity used during these periods has been adapted from Spalding-Fecher *et al* (1999). It is noted that these percentages reflect national load curves rather than only the Western Cape since they are based on Eskom's data for the residential sector. Table 4.1 shows the percentage share estimation of electricity used during these periods.

Table 4-1: Percentage share of electricity use

Source: Spalding-Fecher *et al* (1999)

Application	*Lighting (%)*	*Space heating (%)*
Peak	9	18
Shoulder	16	10
Off-peak	75	72

The electricity purchase price paid by distributors is required to calculate the electricity purchase costs that will be incurred by the RED. It is not yet known what price Eskom Generation will charge the proposed distributors. For purposes of this analysis the electricity purchase price is assumed to be the average of the price currently charged by Eskom Generation to Eskom Distribution, and the price charged by Eskom Distribution to municipal distributor (in this case the Mossel Bay municipal distributor). This means the peak purchase cost for the distributor is more than the purchase cost at shoulder and peak times. Distribution purchase prices that are used in the analysis are shown in Table 4-2.

Table 4-2: Electricity purchase costs

Period	*Purchase cost c/kWh*
Peak	0.23
Shoulder	0.10
Off-peak	0.06

Project-specific assumptions have been made about prices of technology or material to be installed, lifetime of the projects, size of the programme and overhead costs. Prices of technology or materials are important for determining the extent to which the utility will subsidise customers' purchase of those technologies or materials. In the analysis CFLs are assumed to cost R27 each and incandescent bulb costs R3 each based on Eskom's analysis for their Efficient Lighting Initiative. The gypsum ceiling board is assumed to cost R500 including installation costs.

The lifetime of the project is important for determining the number of installations that will be made in each year. Some studies (Simmonds 1999; Spalding-Fecher *et al* 1999) have assumed a 20-year lifetime for these types of projects. The choice of a ten-year term in this analysis is based on the notion that these investments are made from the distributor perspective that would like to see financial returns within a shorter period.

Programme size refers to the total number of installations and annual installations. Both total and annual installations are important to determine the electricity usage and savings purchase costs, lost revenue and avoided purchase costs for the whole programme. This analysis models the installation of CFLs and ceilings over 10 years. The lighting project is aimed at half of urban households in the Western Cape where each household will be supplied with 3 CFLs. According to 1996 statistics, there were 862 527 households in total in the Western Cape, and out of which 736 349 are urban (Davis 1999; Van Horen & Thompson 1999). So, roughly the lighting project targets 368 000 households which means installing 1 104 million CFL bulbs over ten years, approximately 110 000 bulbs per annum. The thermal efficiency project targets 50% of the RDP houses where a ceiling will be installed in each house. Housing statistics from Department of Housing (DOH) show that currently 11 500 low-cost houses have been built in the Western Cape, and the housing backlog is 162 000 (DOH 1999). So roughly the project targets installing ceilings in 81 000 households over ten years, approximately 8100 ceilings per annum.

Table 4-3: Programme size

	CFLs	*Ceilings*
Total no. of installations	1 104 000	81 000
Annual installations	110 000	8 100

Estimations of start-up and annual costs of both projects are based on the estimation of programme costs used in the study of Spalding-Fecher *et al* (1999) (calculation of programme costs is shown in Appendix 1). Programme overhead costs are presented in Table 4-4.

Table 4-4: Programme overhead costs

	CFLs	*Ceilings*
Start-up costs (R000)	331	30
Annual costs (R000)	396	36

4.4 Results of the financial analysis

The assumptions presented above have been used to calculate the costs and benefits. Detailed calculations are presented in Appendix 2, and only the results of these calculations are presented below.

4.4.1 Project costs and benefits

The interventions would have costs and benefits. Costs that would be incurred include lost revenue and overhead costs. Capital costs would be incurred if the RED decides to subsidise the cost of CFL or ceiling. Benefits include energy savings, and avoided electricity purchase costs. The analysis shows that costs exceed benefits, resulting in a net loss for the distributor in each programme. To show the lifetime financial impacts of each installation on the distributor these costs and benefits are discounted at 15% over 8 years for the CFL and 20 years for the ceilings. The present values of annual costs and benefits over the lifetime of each installation are presented in Table 4-5.

Table 4-5: Present value of annual costs and benefits for single installation of CFL and ceiling

	CFLs	*Ceilings*
Lifetime (years)	8	20
Costs		
overhead costs(R)	(16)	(28)
lost revenue(R)	(104)	(304)
Benefits		
Avoided purchase costs(R)	31	83
NPV(R)	(89)	(249)

Table 4.6: Annual energy savings from single installation of CFL and ceilings.

	CFL	*Ceilings*
Energy savings (kWh)	70	294

By investing in these energy efficiency projects the RED will lose revenue, but it will avoid the purchase costs associated with distributing electricity that would otherwise be incurred if an incandescent bulb is used or a ceiling is not installed. In the case of efficient lighting, since the high wattage incandescent bulbs will be replaced by low wattage CFLs, lost revenue is the difference between revenue derived from use of incandescent bulb and a CFL. The avoided purchase cost is the difference between electricity purchase cost from use of an incandescent bulb and electricity purchase cost from use of CFL. In the case of thermal improvements to housing, lost revenue is the difference between revenue derived from electricity use in a house with a ceiling and house without a ceiling. The avoided purchase costs is the difference between cost incurred in distributing electricity for a standard house without a ceiling and a house with a ceiling. In addition these two projects will result in energy savings, which is the difference between energy use of an inefficient technology and an efficient technology.

4.4.2 Net financial results for the programme

When the results presented above are factored into cash flows for each project the result is a net loss and a negative NPV. This means that the financial impact of energy efficiency interventions is negative. This is because the avoided electricity purchase costs do not offset the project's overhead costs and lost revenue. The full financial analysis of the programmes is presented in Appendix 2. The cash flow results of the programmes are presented in Table 4-7.

Table 4-7: Cash-flow results of energy efficient interventions for distributor

			Total programme impact in year 10			
	Installations in place	*NPV (Rm)*	*Lost revenue (Rm)*	*Overhead costs (Rm)*	*Avoided purchase costs (Rm)*	*Income/ (loss) (Rm)*
CFL	800 000[10]	(49)	(18. 5)	(2.9)	5. 6	(15 .8)
Ceilings	81 000[11]	(10)	(3.9)	(0.365)	1.1	(3.2)

10 In year 10 the lifetime of CFLs (approximately 200 000 bulbs) installed in year 1 and 2 has expired only 800 000 bulbs will be in place.

11 Although the utility would have installed ceilings in 81 000 households, only 50% of these households will use electricity for space heating, which means the utility will incur 50% of lost revenue and avoided purchase costs for the installation of

4.5 Financial impact of energy efficiency programmes on the financial position of the Western RED

In order to determine the total financial impact of energy efficiency investments, the projected income statement of the Western RED is modified by including the results of the analysis of the total programme impact in year 10. Three different scenarios are used to analyse the financial impact of the energy efficiency investments by the Western RED. Scenario 1, which is CFL investment only, involves changing the sales revenue and operating costs by adding the revenue and costs arising from installing CFLs. Scenario 2, which is investment in ceilings only, involves adjusting the sales revenue and operating costs due to installation of ceilings. Scenario 3 is investment in CFLs and ceilings, involves adjusting the sales revenue and operating cost due to installation of CFLs and ceilings simultaneously. It will be assumed that the Western RED's real income statement in year 10 is the projected 1997 income statement prepared by Van Horen and Thompson. The adjustments result in net changes in sales revenue and the operating costs. Deducting the lost revenue from the energy efficient intervention brings the change in the RED's sales revenue. The operating costs are adjusted by including the overhead costs and deducting the avoided purchase costs. These adjustments are shown in Table 4-8.

Table 4-8: adjustments in the income statement of the Western RED

	Year 10 income statement (Rm)	*With CFL investment (Rm)*	*With ceilings investment (Rm)*	*With CFL and ceilings (Rm)*
Income statement				
Sales revenue	2271	2253	2 267	2249
Operating costs	(1750)	(1742)	(1749)	(1747)
Municipal transfers	(252)	(252)	(252)	(252)
Operating surplus	269	252	266	250
Interest paid	(35)	(35)	(35)	(35)
Net surplus	234	224	231	215

The energy efficiency investments cause a decrease in the sales revenue and operating costs of the RED. Even though the avoided electricity purchase costs are bigger than overhead costs, the net loss in revenue is even larger. Thus the net changes cause a decrease in operating and net surplus. However these changes do not make the RED to go bankrupt. It is still generating profit and thus its financial viability is not affected. Provision of regulatory mechanisms to encourage the RED to invest in energy efficiency will cost the regulator, but the cost will be small relative to the size of the industry.

4.6 Conclusion

The results of this analysis show that, whilst the energy efficiency investments provide energy savings, loss of sales revenue is a major issue for utilities. Although there is a benefit arising from avoided electricity purchase costs, the programme's overheads and lost revenue are substantial and thus offset this benefit. This means that, from the distributor's perspective, energy efficiency investment results in a net loss.

When these results are used to modify the projected income statement of the Western RED, the operating and net surpluses decrease because of lost revenue. With current pricing and licensing regulations, therefore, the RED cannot invest in or promote energy efficiency because of negative financial consequences. It is possible that energy efficiency initiatives could fall by the wayside, because they reduce electricity consumption and sales. Electricity distributors as retailers depend on electricity sold to get profit, and would not voluntarily encourage energy efficiency. Therefore, regulatory mechanisms that would provide distributors with financial incentives are needed to encourage promotion of energy efficiency at distribution level. The next chapter provides recommendations on regulatory and other mechanisms to deal with energy efficiency in the restructuring EDI.

5. Recommendations and conclusion

5.1 Introduction

This research has outlined the theory of DSM, and energy efficiency and provided a selection of case studies on how DSM, particularly energy efficiency is practised in other countries. It identified barriers to energy efficiency from the distributor's perspective and analysed the extent to which energy efficiency investments affect the profitability of the distributor.

The main finding is that distributors in the current, and more importantly the new, EDI structure are unlikely to invest in energy efficiency even if they do invest in other kinds of DSM. This chapter addresses the question of what should be done to encourage distributors to promote energy efficiency oriented DSM. This question will be answered by, firstly, summarising findings presented in this research to provide the context of the recommendations; secondly, making recommendations that will address barriers inhibiting distributor's investment in energy efficiency. A conclusion that covers policy strategies to encourage distributors to promote energy efficiency and areas for future research is presented.

5.2 Summary of research findings

The review on country case studies illustrates energy efficiency oriented DSM experience before and after restructuring of electricity markets from both industrialised and developing countries. This experience is valuable to South Africa, which operates both in industrialised and developing country contexts, and which is about to restructure its electricity market. Industrialised country experience shows that regulatory mechanisms that provide financial incentives to support utility investment in energy efficiency programmes and IRP with energy efficiency oriented DSM as a central component were effective mechanisms in promoting energy efficiency. These are still relevant in South Africa because full retail competition is not likely to be introduced in the near future. There are various techniques that can be used to implement energy efficiency programmes. Those that have produced positive results are comprehensive programmes that include information programmes, performance based standards, direct installation, bidding, performance contracting and rebate programmes. Not all of these will be suitable in South Africa. For example, performance-contracting programmes are implemented by ESCOs, and at the moment ESCOs in South Africa are limited and do not offer energy efficiency services. The developing country experience shows that it is possible for government to play an active role in promoting energy efficiency by financing programmes and through legislation such as codes and standards.

As outlined in Chapter One the overall objective of this research is to examine the potential impact of the proposed structure of electricity distribution industry on energy efficiency. It is premised on the following specific objectives:

- To investigate energy efficiency activities in the current and proposed distribution structure;
- To determine the financial implications of energy efficiency investments on the financial position of the proposed REDs;
- To investigate the current and planned regulatory measures that encourage distributors to promote energy efficiency;
- To formulate recommendations that will ensure promotion of economically viable energy efficiency programmes in the proposed structure of the EDI.

Currently, Eskom Distribution and municipal distributors are not keen to implement energy efficiency oriented DSM. They are more in favour of implementing other types of DSM such as load shifting. This stems from the motives that drive distributors and a lack of information about energy efficiency. Distributors implement DSM to reduce peak load and not electricity consumption. In addition, distributors rely on surpluses derived from electricity sales, so distributors are not interested in energy efficiency investments that would reduce sales. Distributors lack information on how investment in energy efficiency could benefit them, and are not fully informed on different energy efficiency opportunities, methods and tools, benefits and costs and how they are implemented. They perceive DSM as only a direct load control tool and overlook consumer energy efficiency options. Particularly at the municipal level, poor understanding of DSM by councillors, who are the municipal decision-makers, impacts on the priority given to energy efficiency in municipal policy, planning and investment decisions.

Financial analysis of energy efficiency strategies shows that distributors would be worse off financially if they invest in energy efficiency projects. This is because energy efficiency measures reduce electricity demand which, without an adjustment to tariffs, reduces the distributor's electricity sales revenue and profit. The benefit that arises due to decrease in electricity purchase costs as a result of energy efficiency is offset by the resulting loss in revenue and increased overhead costs.

Currently there is no specific legislation or regulation for the promotion of energy efficiency by electricity distributors. There is no Act that emphasises codes and standards to enforce energy efficiency measures. In addition there is tension between policy objectives on setting electricity prices and energy efficiency objectives. The White Paper on Energy Policy gives priority to both energy efficiency and low electricity prices. Whilst the government's rationale in its requirement for lower electricity prices is to ensure affordability of electricity to poor people, it is difficult to achieve energy efficiency initiatives in an environment where electricity prices are low, because low electricity prices are a disincentive to investment in energy efficiency. The NER is unlikely to set electricity prices that are based on marginal costs, even though having a low kWh price is not what is important, but rather the price of electricity services.

The regulatory measures suggested by the NER are insufficient to promote energy efficiency or to provide incentives to distributors to invest in energy efficiency measures. As noted by Ellman (1999b) the NER has insufficient human resources, which will negatively affect its ability to carry out IRP that could support energy efficiency investments. IRP is complex and requires special skills and large amounts of highly accurate data, which is difficult and expensive to obtain. Furthermore, the NER is overloaded with tasks of rationalising tariff structures and setting retail prices. This state of affairs in the NER will decrease its capacity to prioritise energy efficiency concerns with the implication that for some time the progress of energy efficiency in South Africa could be sidelined. Distributors themselves do not understand the rationale for the IRP and are not well equipped to implement it. This implies that, possibly, distributors in the end will not do IRP in the short term. Other measures, besides the IRP, are still under discussion and nothing has been spelled out yet.

In summary, this research has identified problems that inhibit distributors to invest in energy efficiency in the current and possibly new EDI as the following: lack of suitable regulatory and legislation mechanisms that provide financial incentives; lack of information about energy efficiency and electricity prices that are below marginal costs. These problems indicate that energy efficiency is at risk without some intervention by the NER and DME and some concerted effort by distributors. The following section recommends the policy strategies to deal with each of these problems

5.3 Policy recommendations to encourage distributors to promote energy efficiency

5.3.1 Role of the NER: providing financial incentives through regulatory mechanisms

Energy efficiency from the distributor's perspective brings about a reduction in electricity sales, which reduces their profitability. Distributors will therefore not promote energy efficiency unless financial incentives are provided. The three regulatory mechanisms that can be adopted by the NER to provide financial incentives to distributors to promote energy efficiency are revenue targets, decoupling sales from revenues and profits, and net-lost revenue adjustments (NLRAs). Apart from these three mechanisms, the NER must move towards setting electricity prices at marginal cost.

Revenue targets

With revenue targets, the regulator begins by setting an allowed level of revenues based on actual costs. Electricity prices are then derived from the allowed revenues and the expected level of sales. Over time, the allowed revenues can be adjusted to account for inflation and productivity. If revenues deviate significantly from those forecast because of energy efficiency investment, the difference will be returned to, or recovered from, ratepayers through periodic adjustments. This reconciliation process is undertaken by way of a balancing account, and it ensures that there are no profits or losses due to unanticipated changes in sales.

Decoupling sales from revenue and profits

Regulatory tariff structures often link energy sales with utility revenues and profits, which is a clear disincentive for the utility to engage in any energy efficiency that reduces sales. As a means of overcoming this disincentive, the NER can design the rate structure such that the income to the distributor is not dependent on sales volume but on some other measure of service. Instead of letting revenues grow with increasing kWh sales, decoupling allows revenues to grow with other factors independent of changes in actual electricity use. Decoupling is appropriate for large DSM programmes where the difference between the retail price and short-term costs is large. It is also suitable where the regulator has limited staff resources to monitor the utility's DSM programmes. The NER should consider this method whilst rationalising tariff structures and setting retail prices.

Net-lost revenue adjustments

NLRAs are designed to compensate utilities for changes in revenue associated with utility DSM programmes. To implement an NLRA, the utility should first estimate the energy load reductions caused by its DSM programmes for the year in question. These reductions, which are energy savings, are multiplied by the difference between retail price and short term energy and capacity costs so as to derive lost energy and lost capacity revenues. The lost energy and lost capacity revenue are added and this is the net lost revenue caused by the utility's programme. It is called *net* because it is equal to the difference between the reduction in utility revenue minus the reduction in utility cost. NLRAs are best suited for utilities that operate only small programmes. The NER could initially use the NLRA mechanism since it is likely that distributors will start off by implementing a few programmes of energy efficiency on a small scale.

These are the simplest regulatory mechanisms that are suitable in the current South African context. The NER should train personnel who will be able to implement these measures.

Moving towards cost reflective pricing

In South Africa, electricity prices do not include long-run marginal costs and environmental costs such as external costs in electricity production, transmission and distribution. Setting prices at marginal cost would not only promote energy efficiency but also promote greater economic efficiency over time. The rationale for this is that, if energy user pays for all the costs of supply, then it is the user's choice whether to use more or less energy. According to Spalding-Fecher *et al* (1999b), while including long-run marginal costs and internalising all externalities in the price of electricity would result in full-cost pricing, it could be in conflict with other social objectives. If electricity prices increase, poor South Africans will not be able to afford it. At the same time, keeping electricity prices low is regarded as an economic strategy to keep South Africa internationally competitive. Industries that are designed to promote economic growth enjoy low electricity tariffs. However, if electricity prices are kept low to effect both social and economic development at the same time, would encourage excessive electricity consumption. This will be problematic because domestic and international pressures and standards are moving towards stricter environmental controls (Spalding-Fecher *et al* 1999b). South Africa should move towards cost reflective prices to generate right signals to end-users, manufacturers and government. However a provision should be made for the poor through a poverty lifeline tariff.[12] This policy should not only be applied to electricity but should be effected in prices of oil, gas and coal as well.

5.3.2 DME's role in promoting distributor investment in energy efficiency

Lack of information and poor understanding of energy efficiency oriented DSM is another variable that contributes to distributors not promoting energy efficiency. Lack of information and awareness about energy efficiency is not experienced only at the customer level. Distributors themselves lack information about energy efficiency benefits.

Clearly it is the DME's responsibility to create an awareness of the benefits of energy efficiency as this is stated as a policy objective in the White Paper on Energy Policy. To achieve this objective the DME should embark on an information and education campaign that emphasises the realisable benefits associated with efficient energy use. Since the DME itself is not well equipped with information on energy efficiency, an agency should be established and be charged with the task of disseminating information related to energy efficiency. Although the establishment of the National Energy Efficiency Agency was initiated it has not been carried forward due to DME's new priorities and resource constraints. Nevertheless, government should reinforce this initiative and put the National Energy Efficiency Agency into operation, to provide information on benefits of energy efficiency targeting distributors, end-use customers, industries and all other players in the energy sector.

Since information programmes alone are not sufficient in promoting energy efficiency, the government can institute energy efficiency standards for lighting and thermal efficiency in housing. The two basic types of energy-efficiency standards are prescriptive standards and performance standards. Prescriptive standards mandate that a certain technology must be used. Generally, prescriptive standards are simpler and are used to govern the efficiency of various types of components and equipment. They are advantageous for improving the energy performance of lighting equipment replacements in existing buildings and facilities.

Some countries have appliance and building energy performance standards. Appliance energy-performance standards are commonly applied to refrigerators, freezers, water heaters, lights and air conditioning equipment. These standards have had an impact in

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[12] Poverty lifeline tariff is a special tariff designed for the poorest of the poor (indigents). Indigents are defined as those people who due to a number of factors are unable to make any monetary contribution towards basic services, no matter how small the amount is (NER 1998).

reducing energy use. Building standards have been developed for lighting and thermal improvements in houses. DME should work with the DOH and facilitate government's establishment and approval of a building code in South Africa, which at least emphasises that a newly built house should have ceiling and efficient lights.

5.3.3 Promoting distributor involvement in energy efficiency

Distributors are in a unique position to assist customers with energy efficiency because they are in constant contact with end-users. They know who their customers are, know their energy consumption habits, communicate with them every month, have well established payment collection mechanisms, and are in a position to collect and analyse data. They are traditionally responsible for providing network energy services. They have the technical know-how and human and financial resources. Legislative and regulatory mechanisms suggested above could encourage distributors to capture cost-effective energy efficiency opportunities that reduce the total cost of providing electricity services. Thus when the financial incentives are in place distributors could implement the two energy efficiency programmes suggested in this research, namely installing efficient lights and improvements to thermal efficiency in low cost housing. Experience shows that the energy efficiency programmes that have produced positive results are comprehensive programmes that include information programmes, performance based standards, direct installation, bidding, performance contracting, rebate and market transformation programmes.

Distributors can start to actively promote energy efficiency through information programmes, financial incentives to end-users and obtaining funds from external sources.

Information programmes to encourage awareness

To provide information distributors could team up with DME to implement aggressive information and awareness campaigns. Dissemination of information can help in building customer awareness. One of the distributor's concerns identified in this research was that current awareness about energy efficiency is low across all income levels. To address this barrier, distributors could implement a broad-based public education campaign. The aim of the campaign would be to teach residential customers about energy efficiency in general and about energy efficient lighting and thermal efficiency of dwellings. Because thermal efficiency is directed to low cost housing, potential owners of RDP housing and builders should be targeted and be provided with information before building the houses. Distributors should develop links with customers, builders, schools, retailers and manufacturers. In addition various channels that can be used include local, regional and national radio and television, and forms of print media including local newspaper and magazine articles, advertisements and informational brochures

Financial incentives to encourage end-user participation

To promote installation of CFLs the distributor can first experiment with direct installation programmes and free CFL distribution targeted at low-income households. For the middle- and high-income groups, rebates and leasing programmes may be more suitable. The distributor can allow 30% reductions on the purchase of two CFLs. It can simultaneously lease CFLs to customers at 30% cost of CFL per month which can be included on the customers monthly electricity bill untill the customer finishes paying off the CFL amount. To cater for customers who use prepayment meters the distributor can incrementally raise prepay customer's kilowatt-hour tariff while the lamps are being paid off.

To improve thermal efficiency in low cost housing a distributor can install ceilings in the planned RDP houses. A ceiling costs R500, which is a substantial amount for low-income households. To ease this financial burden, a distributor can work jointly with the state to increase the subsidy allowed for low cost housing. For example the cost of installing a ceiling can be included in the total cost of the housing structure and the distributor commits to pay a portion of this cost.

Obtaining funds from external sources

To deal with financing barriers, distributors could mobilise overseas funds to enable customers to participate in energy efficiency. Since the limited number of ESCOs in South Africa do not provide energy efficiency services, distributors are in a favourable position to source external funding for energy efficiency and directly install energy efficient technologies. Electricity in South Africa is produced by burning coal, which produces large quantities of CO_2, and the main GHGs connected with climate change. Efficient lighting and thermal improvements to housing reduce the amount of energy used by households for lighting and space heating, and thus reduce the amount of GHGs released into the atmosphere. Therefore projects targeted at installing CFLs and ceilings in low–cost housing are eligible for funding through programmes targeted at reducing GHG emissions such as the Global Environment Facility (GEF) (Simmonds 1997; Spalding-Fecher 1999). This funding could help distributors reduce capital costs related to investments in energy efficiency. Eskom, for example, has obtained funds to develop a programme to disseminate CFLs into the residential sector of South Africa. This should be taken over by REDs when they are in place.

5.4 Conclusion and areas for future research

South Africa's White Paper on Energy Policy states that energy efficiency is a strategy to fulfil the energy needs of poor people in South Africa. What is required now are policy strategies to fulfil the policy objectives. This research has explored policy strategies. These policy strategy recommendations are based on the fact that energy efficiency programmes yield societal benefits and are therefore worthwhile investments for the society as whole.

The first strategy is that government through its legislative and regulatory arms should encourage electricity distributors to offer energy efficiency programmes by removing information, financial and electricity pricing barriers. In the current EDI structure, distributors are public entities, likewise, in the proposed EDI structure government will still own REDs. Therefore public support for energy efficiency cannot be escaped. This public support could be achieved by putting in place appropriate regulatory mechanisms that provide distributors with financial incentives to promote energy efficiency. In addition the government should legislate energy efficiency through instituting energy efficiency standards for lighting and thermal improvements to low cost housing. The government can pass legislation that CFLs and ceilings should be installed in the construction phase of the all RDP houses.

The second strategy is that distributors should implement energy efficiency programmes. Distributors should actively promote energy efficiency by providing information and financial incentives to end-users and mobilise finance from external sources such as multinational lending institutions that provide finance for energy efficiency and environmentally friendly investments.

The third strategy is that information and educational programmes should be taken as essential components of energy efficiency programmes by government and distributors. Therefore the DME and distributors should work together to disseminate information to improve end-user awareness about energy efficiency.

As has been identified in this research, there has been little investment in energy efficiency by distributors in South Africa. As the electricity industry structure is about to be changed it is possible that energy efficiency, because it is a public good, could be sidelined. A far-sighted, adequately funded investigation into this question is certainly justified. The investigation needs to focus on identifying other obstacles that inhibit distributors to promote energy efficiency. This research has identified that there are no regulatory mechanisms that sufficiently target promotion of energy efficiency. Further research on regulatory mechanisms that are suitable in the South African context is necessary, especially when the new EDI structure is in place. The timing of this research is appropriate since this discussion provides input before the REDs are in place. In particular, it contributes to the debate around the future of energy efficiency before restructuring has been finalised, and thus will hopefully positively influence the prospects for investment in energy efficiency programmes.

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Appendix 1:
Assumptions used in the financial analysis of the two energy efficiency interventions

Time frame and scope of financial analysis

The two energy efficiency projects that are considered in this analysis are installation of energy efficient lights and ceilings to low-cost housing. The financial analysis will determine the impact of these energy efficiency interventions on the RED over ten years.

Installing energy efficient lights per household is aimed at 50% of households in the jurisdiction of the proposed Western RED. Installation of ceilings to low-cost houses is aimed at 50% of the low-cost housing that still need to be built in the jurisdiction of the Western RED. In the Western Cape approximately 115 000 RDP houses have been built, with a housing backlog of 162 000. The houses that have been built so far are without any consideration of environmentally sound principles including thermal improvements.

This financial analysis begins by looking at one bulb or one ceiling per house, and then at the impact on the Western RED.

Methodology

Cost effectiveness of the selected energy efficiency interventions is determined by using the "Standard Practice Methodology for Economic Analysis of DSM" which is the principal approach in screening and analysing DSM programmes. The Standard Practice Methodology defines five specific tests, namely the Participant Test, Utility test, Rate Impact Measure (RIM) Test, Total Resource Cost (TRC) Test and the Societal Resource Cost Test (Davis et al 1993).

Since distributors are retailers of electricity, questions concerning financial viability of a proposed project are most important. From their perspective the Rate Impact Measure Test, also known as the Utility Revenue Impact Test, provides answers to these questions. The Revenue Impact measure is useful for informing management of financial implications of the DSM programme (Kahler 1999).

The utility revenue impact test

This test specifically examines the revenue impact of a DSM programme and compares the revenue loss and programme cost against the energy and capacity benefits as a result of the programme (Spalding-Fecher *et al* 1999). The test is based on a cash flow stream of project costs and benefits. Project costs that are factored in the cash flow are costs that arise as a result of a decision to invest in the DSM project. These project costs are usually overhead costs, purchase costs and lost revenue from lost sales as a result of the project. Project benefits should reflect any and all net benefits that accrue to the project. These benefits include energy savings and avoided electricity purchase costs. To determine whether the utility is a net winner or loser as a result of the project the cash flow should be discounted to determine its Net Present Value (NPV). The discount rate to use in this analysis is the utility's cost of capital. A positive NPV indicates that the utility benefits from the investment, whereas a negative NPV shows that the utility will loose by making the investment.

There is the possibility that additional electricity savings by the consumer will be compensated by additional consumption of other electrical service. This will result in additional revenue and supply costs for the utility (take-back effect).

In summary the main impacts on the utility's revenue will arise from:

Costs: lost revenue and programme overhead costs

Benefits: Avoided purchase costs.

For purpose of this analysis the utility revenue impact test is used to determine financial viability of the energy efficiency interventions, from the distributor's perspective. The assumptions are discussed in the following sections.

General assumptions used in the analysis

Discount rate

A discount rate reflects the time value of money and is used in the calculation of the present value of future costs and revenues. There are three types of discount rates. First is the social discount rate, which is used to determine whether an investment is in the national or economic context. The other two discount rates are the utility discount rate and the consumer discount rate. The utility discount rate reflects the cost of capital available to the utility, while the consumer discount rate reflect the cost of capital available to the consumer (Spalding-Fecher *et al* 1999).

The relevant discount rate in this analysis is the utility discount rate. For purposes of this analysis the assumed discount rate which reflects the cost of capital available to the RED is 15%. This is based on the notion that the RED will operate on business principles and will obtain capital at private competitive rates.

Energy prices

The analysis on prices done by Davis (1999) shows that the weighted average electricity price to end-users after rationalisation is complete will be 19.2 c/kWh, but domestic prices are likely to be higher than this so as to recoup electrification costs. According to Davis (1999), Swannevelder (1999), and Bothma (1999), real domestic tariffs are likely to remain at 33c/kWh the current Eskom Homelight rate. For purposes of this analysis 33c/kWh is taken as the electricity tariff that will be paid by all customers.

Residential load curves and peak electricity use

Load curves indicate the electricity consumption patterns during different periods such as peak, shoulder and off-peak. The load curve of electricity consumption is used in the calculation of electricity purchase costs and revenue (Spalding-Fecher *et al* 1999). In Eskom, peak times are taken to be from 18: 00-20:00 Monday to Friday and shoulder period is taken as 8:00-10:00 and 20:00 – 21:00 Monday to Friday. Off peak periods are all other times and all weekends.

The calculation of the percentage of electricity used during these periods is done by taking the average of load curves of townships and newly electrified households (taken from Eskom's data for residential sector). The different load curves experienced in summer and winter are also incorporated in the results (Spalding-Fecher et al 1999).

For purposes of this analysis it will be assumed that the peak, shoulder and off-peak times are similar to those determined by Eskom. The percentage of electricity used during peak, shoulder and off-peak times for lighting and space heating are shown in Table1 below.

Table 1: Percentage use of electricity at peak, shoulder and off-peak periods

Source: Spalding-Fecher *et al* 1999

Time	*Lighting %*	*Space-heating %*
Peak	9	18
Shoulder	16	10
Off-peak	75	72

Electricity purchase costs

In the current EDI distributors pay different cost prices for electricity purchases. Eskom Distribution purchases directly from Eskom Generation, while municipal distributors purchase electricity from Eskom Distribution. The charges at these interfaces are different.

In the REDs scenario distributors will purchase electricity from Eskom Generation. It is not yet known what price Eskom Generation will charge to distributors. For purposes of this analysis the electricity purchase price that will be paid by the RED is obtained by taking the average of what is paid by Eskom Distribution and municipal distributor (in this case Mossel Bay municipality).

Table 2: Eskom and Municipal Distribution electricity purchase price

Source: Kahler (1999), Mossel Bay Municipality (1999)

	Eskom Summer (c/kWh)	*Eskom winter*	*Municipality Summer (c/kWh)*	*Municipality winter (c/kWh)*	*Average price (c/kWh)*
Peak	0.19	0.21	0.19	0.21	0.20
Shoulder	0.11	0.12	0.11	0.11	0.11
Off-peak	0.06	0.07	0.06	0.06	0.06

Avoided costs of distribution

The Western Cape urban areas are close to 98% electrified. This means that no capital and upgrading costs will be avoided by reduced energy demand resulting from the energy efficiency investments. So, the distributors will obtain significant cost reductions in operating costs such as electricity purchase costs.

Programme specific assumptions

Assumption for energy efficient lighting

Lamp related assumptions

Table 3: Lamp related assumptions

Source: Spalding-Fecher *et al* (1999)

	CFL	*Incand. bulb*
Cost of lamp	R27.00	R3.00
Lifetime (hours)	8000	1000
Power rating (Watts)	15	75
Hours of use per day	3.2	3.2

Programme size

There are 862 527 households that will be served by the Western RED; 736 349 are urban households (van Horen & Thompson 1998). The assumption made for purposes of this analysis are that half of the urban households will be considered for the energy efficient lighting programme. It is assumed that three bulbs will be installed in each household. The programme is implemented over 10 years. The total number of bulbs required for the programme and the number of bulbs required per year is a function of the number of households included in the programme.

Table 4: Programme size of energy efficient lighting programme

Total number of households (R000)	736
Households included in the project (R000)	368
Number of bulbs per household	3
Total number of bulbs required for the project (Rm)	1 104
Life of project (years)	10
Bulbs required per year (R000)	110

This shows that there will be approximately 1.1 million bulbs required for the programme which means approximately 110 000 bulbs required per year for a period of ten years.

Programme overhead costs

The programme costs in this analysis will be extrapolated from the estimation of programme costs in the study by Spalding-Fecher *et al* (1999) which will be used as the reference study. This reference study targeted installation of 2.5 million CFL bulbs over 20 years, approximately 125 000 bulbs per annum. The start-up costs were estimated to be R750 000 and R450 000 as annual costs (Spalding-Fecher *et al* 1999).

As shown in Table 4 this project targets installation of approximately 1.1 million bulbs over ten years. Start-up cost would be obtained by dividing total number of bulbs required for this programme by the target total number of bulbs in the reference study, multiplied by estimated start-up costs used in the reference study.

Start up costs = 1. 104 million bulbs/ 2.5million bulbs)*R750 000 = R331 200

The start up costs per bulb will be R331 200/1.104million bulbs = R0.30

Annual programme costs will be obtained using the same method described above.

Annual costs = 110 000 bulbs/125 000 bulbs* R450 000 = R396 000

Annual costs per bulb will be; R3 96 000/110 000 = R3.60

Table 5: Estimation of programme overhead costs for energy efficient lighting programme

	Single bulb(R)	*Entire programme (R000)*
Start-up costs	0.30	331
Annual costs	3.60	396

Assumptions for thermal improvements to low cost housing (installation of ceilings)

The analysis of financial implications of installing ceilings in new formal houses provided to low income households under the national government subsidy scheme is based on the following assumptions:

Cost of ceiling

There are different types of ceiling materials with varying costs. In addition these types of ceilings have different thermal properties and energy cost saving potentials. According to

Simmonds (1997) the financial analysis of ceiling material showed that the Gypsum board which cost R500 has the best financial return. It is assumed that Gypsum board will be installed in all the houses considered for the project.

Programme size

The current policy in South Africa is that households earning less than R3 500 per month are eligible for RDP subsidised housing. A maximum amount of R15 000 is paid to beneficiaries on a project-linked or individual basis (DOH1998). Housing statistics from DOH (1999) show that in the whole of South Africa there are 6.7 million households earning less than R3 500 per month. Out of these households approximately 2.2 million do not qualify for the current low-cost housing scheme as they may have received housing from the previous government, inherited houses, or built houses from their own efforts without government assistance, so government has provided 797 000 houses nation-wide. This brings the housing backlog to 3.7 million.

In the Western Cape there are 594 000 households earning less than R3 500 per month. Out of this amount 316 000 households do not qualify for housing under the new scheme. 115 000 houses have been provided, so the housing backlog is 162 000.

For purposes of this analysis it is assumed that 50% of the 162 000 houses that still need to be built in the Western Cape will be considered for the installation of ceilings over ten years. This means installing a total of approximately 81 000 ceilings and 8 100 ceilings per year.

Table 6: Estimation of programme size of thermal improvements to low-cost housing

Total low cost housing backlog	162 000
Number of houses for the project (50% of housing backlog)	81 000
Total number of ceilings required for the project	81 000
Life of the project	10
Ceilings required per year	8 100

Overhead costs

Programme overhead costs are estimated based on the extrapolation from the programme costs of Spalding-Fecher *et al* study which targeted installation of 2 million ceilings in low-income households over 20 years, that equates to an installation of 100 000 ceilings per annum.

Start up costs = 81000 households/2 million households*R750 000 = R30 375, start up cost per house will be R0.38.

Annual costs = 8100households/100 000*R450 000 = R36 450, annual costs per house will be R4.50.

Table 7: Estimation of programme costs for thermal improvements to low cost housing

	Single installation (R)	*Entire programme (R)*
Start-up costs	0.38	30 375
Annual costs	4.50	36 450

Appendix 2: Calculations

Electricity use and electricity savings

In the installation of efficient lights project it is assumed that a 15W CFL replaces a 75W incandescent bulb, whilst in the installation of ceilings project a standard house without a ceiling will be replaced by a house with a ceiling. It is important to calculate energy usage by each application so as to determine energy savings.

Electricity use: power rating * daily use (hrs)* 365/1000

CFL electricity use: 15W*3.2*365/1000 =18 kWh per year

Incandescent bulb electricity use: 75W*3.2*365/1000= 88kWh per year for each bulb. Electricity savings from use of energy efficient lights will amount to 70 kWh per year for each bulb (88 kWh- 18kWh).

Simmonds (1997) using the QUICK II Model of household thermal efficiency and energy use, estimated that a household without a ceiling consumes 441 kWh in winter for its space heating needs. When a gypsum ceiling is installed this household will consume 147 kWh for space heating. Energy savings that will accrue as a result of installing a ceiling in each household will amount to 294kWh (441kWh-147kWh). However not all low-income households in the Western Cape use electricity for space heating, some use wood and paraffin to meet their space-eating needs (Mehlwana & Qase 1995; Simmonds 1997). It is difficult to determine the number of households using the different fuels for space heating. Mehlwana and Qase (1995) found that 40% households in Cape Town use electricity for space-heating. However these are long established electrified households. For purposes of this analysis it will be assumed that 50% of the households who will be installed with ceilings will use electricity for space heating.

Avoided electricity purchase costs

Since the households will use low wattage CFLs instead of high wattage incandescent bulbs, electricity consumption for lighting will be reduced. Likewise, in households that use electricity for space heating, the installation of a ceiling will reduce their electricity consumption for space heating. There will be a change in purchase costs due to use of low wattage CFLs and installation of ceilings.

For the lighting project the avoided electricity purchase costs would be:

Single installation: electricity purchase costs for an incandescent bulb minus electricity purchase costs for CFL bulb = R8.36-R1.41 = R6.95. Since a CFL last approximately 8 years, at a discount rate of 15%, installing a single bulb would avoid electricity purchase costs to the value of R31.

Avoided electricity purchase costs for the installation of ceilings would be:

Single installation: electricity costs in household without a ceiling minus electricity purchase costs in household with a ceiling = R40 - R13 = R27. However to reflect the fact that only 50% of households will use electricity for space heating, the lost revenue per household should be weighted to reflect this, therefore the weighted lost revenue per household will be R13 and this equals to NPV of R83 at 15% discount rate over 20 years.

Lost revenue

Revenue is lost because of lost sales due to low electricity consumption of an efficient application.

Revenue loss from single bulb can be expressed as (Incandescent bulb energy use* tariff) - (CFL energy use* tariff)= (88kWh*0.33c/kWh)-(17.52 kWh* 0.33c/kWh) = R28.91- R5.78 = R23.13. This lost revenue per bulb is discounted at 15% to determine the revenue lost by each bulb over its 8 year lifetime and this equals to R104.

Lost revenue for single installation of ceilings can be expressed as energy use in household without ceiling multiply by electricity Homelight tariff minus energy use in household with a ceiling multiply by electricity Homelight tariff = (441kWh*0.33c/kWh)-(147kWh*0.33c/kWh) = R97.00. Over a 20-year period at a discount rate of 15%, lost revenue per ceiling installed would be R607. However to reflect the fact that only 50% of households will use electricity for space heating, the lost revenue per household should be weighted to reflect this, therefore the weighted lost revenue per household will be R48.50, and this equals to NPV of R304 at 15% discount rate over 20 years.

Cash flow of projects

The cash flow is prepared based on the assumption that the distributor will get funds at 15% discount rate. Variables that make up the cash flow stream of the projects are avoided electricity purchase costs, project overhead costs, and lost revenue. The cash flow analysis of both projects shows negative results. Investment in these projects yields loss and negative NPV. This is because the avoided purchase costs are not huge and therefore do not offset overhead costs and lost revenue. The cash flows for these projects are shown in Tables 1, 2, 3 and 4.

Table 1: Cash flow for single installation of CFL bulb over 8 year lifetime of the CFL bulb

Years	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Avoided purchase costs (R)	6.95	6.95	6.95	6.95	6.95	6.95	6.95	6.95
overhead costs(R)	(3.90)	(3.60)	(3.60)	(3.60)	(3.60)	(3.60)	(3.60)	(3.60)
lost revenue (R)	(23)	(23)	(23)	(23.)	(23)	(23)	(23)	(23)
Revenue/ (loss) (R)	(20.08)	(19.78)	(19.78)	(19.78)	(19.78)	(19.78)	(19.78)	(19.78)
NPV(R)	(R89)							

Table 2: Financial result of installing 110 000 CFLs per year over 10 years

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
PV impact of installations (Rm)	(9.79)	(9.79)	(9.79)	(9.79)	(9.79	(9.79	(9.79)	(9.79	(9.79)	(9.79)
NPV programme (Rm)	(49)									

The cash flows for installation of ceiling are presented in Table 3 and 4.

Table 3: Weighted average house cash flow per ceiling over 20-year life time of a ceiling

Years	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Avoided purchase costs	13	13	13	13	13	13	13	13	13	13
Overhead costs	(4.9)	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)
Lost revenue	(49)	(49)	(49)	(49)	(49)	(49)	(49)	(49)	(49)	(49)
(Loss)	(41)	(40)	(40)	(40)	(40)	(40)	(40)	(40)	(40)	(40)

Years	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
Avoided purchase costs	13	13	13	13	13	13	13	13	13	13
Overhead costs	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)	(4.5)
Lost revenue	(49)	(49)	(49)	(49)	(49)	(49)	(49)	(49)	(49)	(49)
Revenue/ (Loss)	(40)	(40)	(40)	(40)	(40)	(40)	(40)	(40)	(40)	(40)
NPV	(249)									

Table 4: Financial result of installing 81 00 ceilings per annum for 10 years

	1	2	3	4	5	6	7	8	9	10
PV impact of installations(Rm)		(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
NPV of programme(Rm)	(10)									

Table 5: Programme impact in year 10

	CFLs	Ceilings
installations in place in year 10	800 000[13]	81 000[14]
Costs		
overhead costs(Rm)	(2.9)	(0.365)
lost revenue(Rm)	(18.5)	(3.9)
Benefits		
Avoided purchase costs(Rm)	5.6	1.1
Income / (Loss) (Rm)	(15.8)	(3.2)

Impact of energy efficiency investments on financial position of the RED

In order to determine the total financial impact of energy efficiency investments, the projected income statement of the Western RED is modified by including the results of the analysis presented above. Three different scenarios are used to modify the financial position of the energy efficiency investments in the Western RED. Scenario 1, which is CFL investment only, involves changing the sales revenue and operating costs by adding the revenue and costs arising from installing CFLs. Scenario 2, which is investment in ceilings only, involves adjusting the sales revenue and operating costs due to installation of ceilings. Scenario 3 is investment in CFLs and ceilings, it involves adjusting the sales revenue and

13 This figure is adjusted to capture the fact that bulbs that would have been installed in year 1 and 2 (approximately 2m bulbs) will not be in working order because their lifetime would have expired.

14 Although the utility would have installed ceilings in 81 000 households in year 10, it is assumed that only 50% of these households will use electricity for space heating, therefore this is reflected in the lost revenue and avoided electricity purchase costs.

operating costs due to installation of CFLs and ceilings simultaneously. These adjustments are shown in Table 5.

Table 5: 3 scenario adjustments in the income statement of the Western RED

Income statement	*Base line*	*With CFL investment*	*With ceilings investment(Rm)*	*With CFL and ceilings*
Sales revenue	2271	2253	2267	2249
Operating costs	(1750)	(1748)	(1749)	(1747)
Municipal transfers	(252)	(252)	(252)	(252)
Operating surplus	269	253	266	250
Interest paid	(35)	(35)	(35)	(35)
Net surplus	234	218	231	215

The adjustments result in net changes in sales revenue and the operating costs. The lost revenue from the energy efficient intervention brings the change in the REDs' sales revenue. The operating costs are adjusted by including the overhead costs and deducting the avoided purchase costs. The resulting net change is not significant because the avoided purchase costs are more than the overhead costs. The result is that there is no significant change in the operating surplus and net surplus of the RED. This leaves the RED in a financially viable position.

Appendix 3: Electricity tariff options

Two part tariff

The objective of the two-part tariff is to charge the household exactly what it costs to supply electricity to that household every month. This is made up of the monthly basic charge and the energy rate. The monthly basic charge is determined by calculating the fixed costs of supply which are the capital costs and the monthly service costs of supply. The energy rate is calculated based on the cost of supplying energy and an additional amount to allow for losses. This tariff structure achieves cost reflectiveness and avoids cross subsidies.

The flat rate tariff or straight line tariff

This tariff structure is designed such that the average consumer would pay the full cost of supply each month. Households consuming less than the average number of units per month would thus be subsidised by some amount. Consumers using more than the average number of units per month thus pay an additional amount above the actual cost of supply. This tariff structure achieves a cross subsidy from the high level (wealthy) consumers to the low level (poor) consumers.

The inclining block tariff

The inclining block tariff structure is generally used for similar reasons as the flat rate structure, namely to achieve a cross subsidy from high level consumers to low level consumers. However instead of charging only one rate, the inclining block tariff charges a lower rate for the first block of energy and higher rate for the second block. Another option of the inclining block tariff structure is to have a third block of energy. With this tariff structure the price level would rise twice as households consume more electricity. The objective of this tariff is to achieve a cross subsidy to low consumption households and also to penalise households with very high levels of consumption, in order to send them a signal that electricity is a resource that should be conserved.

Time of use tariff

Time of use tariff allow the application of different tariffs at different times of the day. Higher charges would be made for electricity consumed during the morning and evening peak period. The objective of this tariff structure is to improve energy efficiency by discouraging energy use at certain times of the day. The consumer can respond in three ways:

- Continue consuming at the same rate and pay higher bills;
- Reduce electricity consumption by more careful use or through the purchase of more efficient appliances or;
- Switch to using electricity at off peak times.

However, this tariff cannot be presently implemented in households for technical reasons, but it remains an ideal tariff mechanism for promoting energy efficiency.

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